ASIATIC
RESEARCHES

ASIATIC RESEARCHES

Comprising

HISTORY AND ANTIQUITIES, THE ARTS, SCIENCES, AND LITERATURE OF ASIA

Vol. The Ninteen

SET OF TWENTY TWO VOLUMES

> *"The bounds of its investigations will be the geographical limits of Asia, and within these limits its enquiries will be extended to whatever is performed by Man or produced by Nature"*
>
> *Sir William Jones*

COSMO PUBLICATIONS
NEW DELHI INDIA

Accession No. 23925
ST. [illegible] L LIBRARY
Gal-90.
86 [illegible]
Dated... [illegible]

First Published 1833
Reprinted 1980

Published by :
Cosmo Publications
24-B, Ansari Road
New Delhi-110002

Printed by :
Mehra offset Press
New Delhi-110002

PUBLISHER'S NOTE

Asia is a vast and magnificent land with a magnificent heritage of civilization and a diversity of cultural strands and traditions. Yet the Asiatic Society, since its inception in 1784 took up this broad canvas for its investigations under the scholarly leadership of its founder Sir William Jones. Dilating on this point in the first annual discourse, Sir Jones declared, "if it be asked what are the intended objects of our enquiries within these spacious limits, we answer MAN and NATURE, whatever is performed by the one or produced by the other." These memorable words have since been paraphrased in the aims and objects of the Society as: "The bounds of its investigation will be the geographical limits of Asia, and within these limits its enquiries will be extended to whatever is performed by Man or produced by Nature."

Sir William Jones had for his colleagues a band of enthusiastic persons with scholarly bent of mind like Charles Wilkins, H. T. Colebrooke, William Chambers, H. H. Wilson, Sir John Shore, Jonathan Duncan and several others. Inspite of being stationed in Civil, Military and Judicial branches of administration, they evinced keen and abiding interest in unfolding the hidden treasures of Oriental learning, and thus laid a solid foundation of the science of Indology or Orientology, to be more precise. These illustrious scholars, undettered by handicaps, faithfully and zealously translated the objectives outlined by the founder in their literary and scientific tracts and dissertations that they presented at the forum of the Society that provided an exciting new dimension to Asian studies. Sir Jones contemplated to publish these fruits of researches by the scholar-members in annual volumes for wider appreciation by the academic world, and the first volume of "ASIATIC RESEARCHES" came out under his own editorship in 1788, three years after the foundation of the Society. Sir Jones was the editor for the first six years i,e. upto 1794. Fourteen more volumes were published under the auspices of the Society upto 1839.

And now Cosmo Publications takes pride in bringing out this first authorised reprint of the "ASIATIC RESEARCHES" complete in 20 volumes. The wide range and variety of subjects dealt with in these volumes present a panoramic view of the civilization and culture of Asia in its different facets and in the different periods of history. There are no less than 367 essays, some amply illustrated in the series of 20 volumes. An analysis of subjects with a select list of names of the contributors, given below, will enlighten readers about their worth.

List of Subjects and Contributors :-

HUMANITIES

1. *Antiquities*........................30 articles.

   Charles Wilkins, William Chambers, John Shore, William Jones, F. Wilford, H. T. Colebrooke, Jonathan Duncan, H.H. Wilson.

2. *History* ....31 articles.

   F. Wilford, William Jones, A. Sterling, H.H. Wilson W. Hunter, J. Prinsep, John Crawford.

3. *Language & Literature*.......37 articles.

   W. Jones, W. Marsden, H.T. Colebrooke, F. Balfour, J. Leyden, B.H. Hodgson, A. Csoma de Koros.

4. *Religion, Manners, Customs and Music*... . ..47 articles.

   W. Jones, H. Vansittart, H. Colebrooke, F. Buchanan, J. Duncan, J. D. Patterson, J. Leyden, W. Carey, John Crawford, H. H. Wilson, B. H. Hodgson, Capt. James Low.

5. *Coins Weights & Measures*...3 articles.

   H. T. Colebrook, Jonathan Duncan, William Jones, F. Balfour.

SCIENTIFIC

1. *Mathematical & Physical Sciences* .... 67 articles.

   T. D. Pearse, R. Burrow, W. Jones, F. Balfour, John Playfair, R.H. Colebrooke, W. Hunter, F. Wilford, W. Lambton, J. Bentley, H.T. Colebrooke, J.D. Herbert, J. Prinsep, G. Everest.

2. *Geology* .... 27 articles.

   H.W. Voysey, J.D. Herbert, P.T. Cautley, H. Piddington, J.G. Gerard, James Prinsep.

3. *Zoology*........................34 articles.

   W. Jones, H.T. Colebrooke, B.H. Hodgson, P.T. Cautley, H.W. Voysey, R. Everest.

4. *Botany*..........................20 articles.

   W. Jones, W. Roxburgh, W. Hunter, F. Buchanan, H.T. Colebrooke, N. Wallich.

5. *Geography* ....24 articles.

S. Turner, R. H. Colebrooke, W. Hunter, J. T. Blunt, W. Lambton, A. Sterling, J.D. Herbert, R. Wilcox, B.H. Hodgson.

6. *Ethnography*....................16 articles.

W. Jones, J. Rawlins, J. Eliot, J. Crisp, R. Wilcox, W. Hunter, J. Prinsep, William Chambers.

7. *Chemistry*.........................2 articles.

J. Prinsep.

8. *Economic & Statistics*........29 articles.

W. Hunter, Col. Polier, H. T. Prinsep, J. Prinsep, Dr. Voysey, J.F. Royale.

I. *Page*

Observations on the Inclination and Declination of the Magnetic Needle. By Lieutenant-Colonel J. A. Hodgson and Monsieur de Blossville. Communicated by Captain J. D. Herbert, ... 1

II.

On a species of Aquila Circæetus and Dicrurus. By B. H. Hodgson, Esq 13

III.

Sketch of the Geology of Central India, exclusive of Malwa. By James Hardie, Esq. 27

IV.

On the Formulæ for calculating Azimuth in Trigonometrical Operations. By Captain G. Everest, ... 93

V.

Memorandum on the Fossil Shells discovered in the Himalayan Mountains. By the Rev. R. Everest, ... 107

VI.

On the Geology of the Peninsula. By Lieutenant S. Charters Macpherson, ... 115

VII.

On the Migration of the Natatores and Grallatores, as observed at Kathmandu. By B. H. Hodgson, Esq 122

VIII.

The Wild Goat, and the Wild Sheep, of Nepal. By B. H. Hodgson, Esq 129

IX.

Page.

On the Ratwa Deer of Nepal. By B. H. Hodgson, Esq. 139

X.

Short Sketch of the Geology of Pulo Pinang and the Neighbouring Islands, with a Map and Sections. By T. Ward, Esq. 149

XI.

Description of the Buceros Homrai of the Himalaya. By B. H. Hodgson, Esq. 169

XII.

On the Compensation Measuring Apparatus of the Great Trigonometrical Survey of India. By Captain Everest, 189

XIII.

Experiments on the Strength and Elasticity of Indian Woods. By Captain H. C. Baker, 215

XIV.

Description of the Wild Dog of the Himalaya. By B. H. Hodgson, Esq. 221

XV.

Observations on the Spiti Valley and Circumjacent Country within the Himálaya. By Surgeon J. G. Gerard, 238

XVI.

Note on the Discovery of Platina in Ava. By James Prinsep, Esq. 279

STATE CENTRAL LIBRARY
WEST BE
CALCUTTA

I.

OBSERVATIONS

ON THE

INCLINATION AND DECLINATION

OF THE

MAGNETIC NEEDLE.

By LIEUTENANT COLONEL J. A. HODGSON,
Surveyor General of India ; and
MONSIEUR DE BLOSSVILLE,
Honorary Member Asiatic Society.

Communicated by Captain J. D. HERBERT, *Assistant to the Surveyor General.*

THE progress which has latterly been made in the investigation of the magnetic phenomena is remarkable. A new science, that of Electro-magnetism, has been created, and the happy conjecture hazarded by PLAYFAIR, that the mysterious properties or powers of matter, which we name gravity, chemical affinity, galvanism, magnetism, electricity, &c. would be one day referred to a single cause, has been almost realized. The very striking facts developed in the thermo-electric experiments have been ably investigated, while the law of the magnetic force has been determined, and the effect of local attraction rigorously calculated. The curious practical result of these latter investigations leading to the correction of that disturbance, under which the magnetic needle on board ship had till then laboured, from the influence of the iron-work about the vessel—offers an example of that utility which, though it may not always be obvious, yet is assuredly sooner or later the fruit of an assiduous cultivation of science.

Nor have the more ordinary phenomena of magnetism been neglected in this general movement. An immense mass of results have been collected by our voyagers to the north pole, relating to the declination and inclination of the magnetic needle, as well as the intensity or directive power. Other observers have assisted, and as far as Europe and the northern regions are concerned, little, perhaps, remains to be desired in this branch of experimental Physics. But with regard to the other countries of the globe, the facts that have been collected are "few and far between." I am happy, therefore, to be able to communicate the following observations made in this country by two members of this Society. We have not yet had any observations of the kind recorded in India, and I doubt not the Society will receive favorably this attempt to fill up the blank that exists. Let us hope, too, that the publication of these results may stimulate other enquirers; and that, by their exertions, we shall yet have correct determinations of the three elements of magnetic inclination, declination, and intensity, at all the principal places of our Indian empire.

The results now offered comprehend the determination of the declination and inclination of the magnetic needle. The first series made on board the French Corvette *La Chevrette*, is by M. de Blossville. I have not thought it necessary to translate his introductory notice, as preferring to retain his own expressions.

Les observations que j'ài faites dans les differens lieux on *La*

Chevrette a touchè comprennent tous les elemens du magnetisme terrestre; mais ·l'etude des plusieurs de ces phénomènes ne pourront fournir des résultats positifs, qu'après avoir repeté a l'observatoire royal de Paris, les épreuves des instrumens qui ont été employés · il ne sera question dans cette notice que de l'inclinaison, et de la declinaison de l aiguille aimantée. Ce n'est egalement qu'après le retour de la Corvette, qu'on pourra s'occuper de tirer des conclusions des observations météorologiques qui ont été faites d'heure en heure avec des barometres et des thermometres tres exacts, pendant toute la durée du voyage."

"L'inclinaison de l'aiguille a été mesurée avec une boussole et quatre aiguilles qui furent mises pour la premiere fois en expérience a l'Observatoire de Paris, en presence et sous la direction de M. Arago, membre de l'Institut, quelques jours avant notre départ. Dans cette occasion, comme dans toutes les autres, lorsqu'une aiguille a ete observée sur ses deux faces; on a changé ses poles avec de forts carreaux et après avoir obtenu une seconde inclinaison, on a eu, en prenant la moyenne des deux, un résultat exempt des erreurs qu'aurait pu produire un defaut d'equilibre. Pour placer l'aiguille dans la direction meridienne magnetique on a cherché d'abord le plan perpendiculaire, ou le plan de l'equateur dans lequel elle se trouve verticale, ou bien, dans les faibles latitudes, on a orienté la boussole d'aprés une mire bien determinée. Quelque fois ces deux methodes ont été employées concurremment et ont offert l'accord le plus parfait. On trouve dans le tableau le résultat moyen des quatre aiguilles."

"Une description de la boussole declinatoire qui nous avait été fournie par *Le depot des cartes et plans de la marine*, serait trop longue, mais les personnes qui l'ont vue a Calcutta se sont convaincus de l'exactitude de cet instrument, et de tous les moyens de verification qu'il reunissait. Dans toutes les experiences on s'est servi de deux aiguilles qu'on retournait sur leurs chapes au milieu des observations et dont on n'a pas renouvellé

le magnetisme pendant toute la durée du voyage. Les deux aiguilles n'ont jamais differé de plus d'une minute dans le relevement des mires dont la position astronomique a toujours été déterminee au moyen d'une circle de reflexion de Borda, par des series nombreuses d'azimuths pris a l'est et a l'ouest."

I.—TABLEAU DES INCLINAISONS ET DECLINAISONS.

NOMS DES LIEUX.	DECLINAISON.		INCLINAISON.	
Paris,	22° 24' 41″	N. O.	67° 51' 42″	N.
Toulon,	19 24 23	N. O.	63 14 0	N.
St. Denis-Ile Bourbon,	14 57 48	N. O.	55 05 51	S.
Calcutta,	2 38 05	N. E.	26 32 38	N.
Chandernagor,	2 39 52	N. E.	26 47 03	N.
Rangoun,*	0 49 52	N. E.	17 51 47	N.
Tringuemalay,	1 08 05	N. E.	3 34 10	S.
Jaffnapatam,	1 16 00	N. E.	0 39 45	S.
Souliperon, Ceylon,	" " "		0 36 34	S.
Aripo, Ceylon,	" " "		2 17 34	S.
Batavia,	0 31 08	N. E.	25 50 01	S.
Pondicherry,	1 02 13	N. E.	3 46 00	N
Karikal,	1 14 01	N. E.	" " "	

* Les observations de Rangoun ont ete faites par le Captn. Fabré, et M. Jeanneret.

This Table is an important addition to our knowledge of the magnetic phenomena. The magnetic equator, it appears, passes at no great distance north of the island of Ceylon, and touches the northern extremity of the island Junkseilon. This would give the place of the magnetic pole, as in lat. 80°, long. W. 105°, being very nearly the position assigned to it by the observations made by Captain PARRY and his associates*. It does not, however, appear that the magnetic equator must necessarily be a great circle of the sphere, or the magnetic pole a mathematical point.

---

* First Voyage. Captain SABINE gives the position as being 60° N. Lat. and 80° W. Long.

The next Table contains the details of some magnetical observations made at the observatory of the Surveyor General's Office, under the direction of Lieutenant-Colonel HODGSON. There being no inclination instrument, or dipping needle, in the depôt, the investigation was necessarily confined to the determination of the declination. The paper gives all the particulars, and details the precautions taken to insure a correct result. One verification which is not touched on in either of the papers I may notice, as it is an important one, and is seldom adverted to.

In making observations with a declination circle—the following is the proceeding. The true azimuth of an object, or its angular distance from the meridian, being determined by other methods, we observe its magnetic bearing by the declination instrument, that is, the angle which the object forms with the direction of the needle. Now this supposes that we can determine the precise point on the limb of the instrument situated in the vertical plane, passing through the line of collimation of the telescope, and also in that passing through the axis of the needle. The first can be done by reversing the telescope, and repeating the intersection of the object, taking the mean of the two readings as the true place of the telescope on the limb. But the second has this difficulty attending it as these instruments are ordinarily made, that the needle being referred to a different set of divisions, unless we are sure that the line marked zero on each accurately correspond, there will be error. This is a point the verification of which is not provided for by any instrument I have seen, although the remedy is obvious enough—that of making the same set of divisions answer for both needle and telescope. This I have understood was the case in M. DE BLOSSVILLE's instrument. To determine the amount of the error, if any, in the instrument used at the Surveyor General's Office, I proceeded as follows:—

A theodolite was set up, and the telescope directed to the declination instrument, which was placed as nearly as could be estimated, so that its plane should be at right angles to the axis of the telescope. The telescope being then made to pass through the 0° and the 180° divisions of the exterior limb was found to form *an angle* with the line of north and south in the compass-box, the wire of the telescope passing to the west of the north end. and to the east of the south end.

It was not easy so to adjust the two instruments that the line described by the cross wires should exactly fall on both 0° and 180°. It was, in fact, found that more satisfactory results were obtained by bringing them on the upper point or 0° by means of the tangent screw, and then estimating the deviation on each of the other three points. As the telescope has a considerable magnifying power, and as the declination circle was within five feet, such an estimate it was found could be performed with tolerable accuracy. To make this clearer, I shall give the detail of one observation:

Cross wires of telescope, on	0°	. 0′	of outer circle.
passes to West of North, ..	0	. 30	inner circle.
——— East of South, ..	0	. 12	inner circle.
——— East of 180°	0	. 10	outer circle.

Here then it is evident, that the cross wires of the telescope, described a line forming an angle of $\frac{0 + 10'}{2} = 5'$, with the line joining 0° and 180° on the outer circle. While it formed an angle of $\frac{30' + 12'}{2} = 21'$, with the line of north and south in the compass-box. Consequently, the latter must have formed an angle with the former of 16′, and by that quantity must the declinations determined by this instrument be erroneous. A second observation gave 15½, a third 13½, a fourth 12½,—mean 14′ 4″.

To understand whether this correction be + or — we are to consider 1st. That the line joining 0° and 180° on the limb, (north end) passed to the east of the line described by the cross wires; 2nd. That the line of north and south in the compass-box (north end) also passed to east, but by a greater quantity. Then the north and south line in the compass-box passed (north end) to east of the line joining 0° and 180° on the outer limb. The point to which the needle should have been adjusted is, consequently, 14′ 24″ west of the point to which it is actually adjusted. Now, let us suppose the magnetic bearing of the meridian taken, it will be 2° 26′ 52″ north-east; but if the point from which the divisions are reckoned, and with it each of the divisions were moved 14′ 24″ west, then the above bearing would be 14′ 24″ more. Adding this quantity to 2° 26′ 52″ we get 2° 41′ 16″ as the correct declination in Calcutta, in February 1828. It is worthy of remark, that M. DE BLOSSVILLE's determination (see Table I.) is 2° 38′, being only 3′ 16″ less. His instrument did not require this correction, as the needle and telescope were referred to the same set of divisions. Whether the circumstance of its having no nonius for reading the sub-divisions will account for the above small difference of 3′ 16″, I cannot pretend to say. It is to be observed, that even with the *same observer and instrument*, the latter furnished with three nonii, two different needles may vary 2′ 24″.

To this cause I am disposed to attribute the discrepancies observable in taking magnetic bearings with different theodolites, which I have found sometimes amounted to 1° 30′. When the magnetic declination is observed with the same theodolite with which the bearings were observed, this becomes a matter of no moment, but it must always be an obstacle in determining the absolute amount of the magnetic declination. For this reason I think no great stress can be laid on the contents of Table III. compiled by Lieutenant Colonel HODGSON, which I, nevertheless, give, as it may attract the attention of the several observers to the subject, and induce them, perhaps, to verify their results in the manner indicated.

Memorandum of Observations made at the Observatory, Surveyor General's Office, Chowringhee, Calcutta, to determine the Magnetic Declination between the 3d February and 24th February, 1828.

" The Declination instrument is made by Gilbert ; the azimuth circle is of eight inches diameter, and divided to 30′ subdividing to single minutes ; the divisions are read by three verniers, at equal distances, and each observation below noted is the result of twelve readings ; i. e., three with the face of the altitude circle to the east, and three to the west, from the north end of the needle, and of as many from the south end. The telescope is of 11¼ inches focal length, and 1⅖ inch aperture, and carries cross wires.

The instrument being placed on a stone pillar at a convenient distance from the transit instrument in the Observatory, out of the influence of iron, and duly adjusted, was correctly laid on the distant meridian mark by causing its centre wire to cover the distant meridian mark, and also the centre wires in the transit telescope, the wire of the declination instrument being reciprocally viewed and covered by the meridian wire of the transit telescope."

The result derived from three Needles, are as follow :

TABLE II.

Date. 1828.		Time.	Barometer by Troughton.	Attached Thermometer.	Detached Thermometer.	Declination East of the North end of the Needle.	Declination West of the South end of the Needle.	Mean Declination East.
		H. M.	Inches.					
February	3	0 40 P. M.				2° 35′ 50″	2° 27′ 30″	
		05 30 P. M.				2 22 00	2 23 50	
	4	09 20 A. M.	29·900	67°	70°	2 25 40	2 28 50	
		00 35 P. M.	20·030	78	79	2 24 00	2 20 30	
		5 15 P. M.	29·864	80	82	2 22 10	2 21 20	
	5	8 55 A. M.	29·902	69	70	2 27 50	2 28 30	
		0 35 P. M.	29·954	77·7	80	2 24 30	2 23 40	
		5 25 P. M.	20·888	80	82	2 22 00	2 28 30	

Date. 1828.		Time.	Barometer by Troughton.	Attached Thermometer.	Detached Thermometer.	Declination East of the North end of the Needle.	Declination West of the South end of the Needle.	Mean Declination East.
		H. M.	Inches.	°	°			
February.	6	8 55 A. M.	30 032	66	69	2° 25′ 50″	2° 30′ 40″	
		0 29 P. M.	30 029	76·5	79	2 21 30	2 26 40	
	7	5 00 P. M.	29·968	82		2 25 30	2 23 00	
	8	8 27 A. M.	30·028	67 5	68	2 22 40	2 28 10	By Needle No. 1.
		0 52 P. M.	30 012	74	77	2 24 40	2 27 20	2° 25′ 22″
		4 40 P M.	29 970	78	80	2 26 20	2 25 30	
	9	7 35 A. M	30 032	58 5	61	2 23 40	2 26 30	
		0 30 P M.	30·600	73	76	2 25 00	2 25 00	
		5 10 P M	30 010	75	78	2 19 00	2 27 50	
	10	0 48 A. M.	30 100	65 5	67	2 23 00	2 30 00	
		0 08 P. M.	30 050	73 5	76	2 23 30	2 26 50	
	11	9 10 A. M	30 054	63	64	2 21 20	2 23 10	
		00 P M	30 018	72 5	76	2 21 40	2 27 00	
		5 00 P M.	29 976	72	74	2 25 00	2 30 40	
	12	9 00 A. M				2 24 50	2 25 00	
		15 15 P. M	29 970	78	79	2 22 10	2 25 20	
	14	8 40 A M	30 088	63	64	2 35 10	2 27 10	
		0 36 P M	30 072	75	77	2 33 30	2 26 20	
		5 12 P M	29 958	78	79 5	2 25 50	2 24 30	
	15	8 15 A. M	30 088	64	65 5	2 31 10	2 25 30	By Needle No. 2.
		0 50 P. M	30 080	77	79	2 27 10	2 26 10	2° 27′ 46″
		5 12 P. M.	30 048	79·5	80·5	2 31 20	2 29 30	
	16	9 00 A. M	30·060	63	65	2 26 40	2 26 40	
		11 50 A M.	30 090	73	75 5	2 29 20	2 23 30	
		4 54 P M	29 920	79·5	80 5	2 28 00	2 23 00	
	17	8 02 A. M.	30 016	60	66	2 28 40	2 26 20	
	19	8 25 A. M.	30·112	66	68	2 23 20	2 29 00	
	22	0 58 P. M	00 072	84 5	86	2 25 30	2 22 00	
		4 27 P M.	30 000	90 5	90	2 29 10	2 29 30	
	23	9 30 A M	30 050	73 5	75	2 33 00	2 26 00	By Needle No. 3.
		0 30 P M.	30 014	83	85	2 29 10	2 26 20	2° 27′ 29″
		5 35 P. M	29 912	89·5	89 5	2 28 30	2 24 30	
	24	9 30 A. M.	30·030	76 5	77 0	2 29 00	2 26 20	
		9 27 P. M.	29 980	83 5	85 5	2 30 00	2 27 10	
		5 42 P. M.	29 926	89 5	90 0	2 27 40	2 27 20	

Mean of Needle, No. 1, ...	2°	25′	22″
No, 2, ...	2	27	46
No, 3, ...	2	27	29
Mean of three Needles, ...	2	26	52
Add error of Zero in Compass Box, ...		14	24
Declination East, ...	2	41	16

" The following are the results of some Observations for determining the Magnetic Variation lately made at places situated at considerable distances from Calcutta, and from each other."

TABLE III.

Date.			Place.	Province or District.	Latitude.	Observer.	Declination.
Year.	Month.						
1813	March	23	Sukeet,	Dooab,	27° 26′ 41″. 2 N.	Major Hodgson,	0° 42′ 00″ East.
	April	11	Beroaly,	ditto,	28 5 32		0 44 00
	May	10	Sesadna,	ditto,	28 59 00 2		0 31 30
	June	21	Rhadana,	ditto,	29 13 40		0 33 45
	Nov.	8	Coel,	ditto,	27 53 13		0 59 00
			Sookertal,	ditto,	29 28 40 6		1 06 00
	Dec.	2	Chandy Pahar,	ditto,	29 55 29		0 37 00
			Dehrah,	Doon Valley,	30 19 11		0 18 08 E.
1814	April		Senspoor,	ditto,	30 23 02		0 28 00
1815	Feb.	8	Bunjary Pokra,	Bettiah,	27 2 29		1 30 13
	May		Distoulia,		26 10 30		1 27 45
1816	March		Seharunpoor,	Dooab,	29 57 10		0 54 00
	April	2	Mohun,		30 33 20 75		0 30 00
		25 or 26	Chour Station,	Hill States,	30 50 27 33		0 50 55
	Dec.	14	Goverdhunpoor,	Dooab,	29 41 19		0 40 00
1817	Feb.	2	Kasheepoor,	Rohilkhund,	29 11 55		0 47 15
1825	Nov.	7		Sylhet,		Lieut. Fisher,	2 21 18
							2 36 00
1827	Dec.		Idyanuh,	Dehli,	20 21 37	Capt. Oliver,	1 28 00
	Nov.		Calcutta,	Bengal,	22 33 46	Capt. Fabre,	2 38 54
			Surveyor General's Office,	ditto,	22 34 00		2 28 36
			Chandernagore,	ditto,	22·50 00		2 39 52
	Dec.	30	Langtofal,	Muncepoor,	24 45 28	Lt. Pemberton,	3 57 09
1823	Feb.	3	Dhoulpoor,	Agra,	26 40 56 5	Capt. Gerard,	1 25 00
			Agra,	ditto,	27 10 20		1 23 00
		22	Nowagaon,	Scindiah's States,	25 56 30		1 19 00
	March	2	Nurwur Fort,	Malwa,	25 38 34		1 01 00
1828	Jan.	24	Kyranuh,	Dooab,	29 33 58	Lt. W. Brown,	1 31 13
			Bal,	Dehli,	29 33 00	Capt. Oliver,	1 25 00
			Tajmahul,	Agra,	27 10 20	Capt. Gerard,	1 09 00
			Dhoulpour,	ditto,	26 41 00		1 11 00
			Gwalior Residency,	Scindiah's States,	26 16 00		0 40 00
			Ditto Lieut. De Voeux House,	ditto,			4 00 00
			Seronge,	Malwa,	24 06 00		0 57 00
			Bhopaul,	ditto,	23 15 00		0 39 00

As upwards of a year had elapsed since the preceding result had been obtained, I thought it would be interesting to determine again this element, in order to judge what might be the amount, and what the direction of the annual variation if any—Table IV. contains the results of this series of Observations, continued from the 23d May to the 9th June. The Observations were made by the same person, with the same precautions, and using the same instrument as in the preceding year; and therefore we may, I think, receive with every confidence the amount of the variation which for fifteen months appears to be 17′ 0″ west, the declination itself being east, and amounting to 2° 41′ 10″ for 1828, and 2° 24′ 10″ for 1829. If this rate should continue, we may soon expect the needle to point due north at Calcutta, after which, I suppose, it will continue to move westward, so as to occasion a westerly declination.

Observations of the Magnetic Declination made at the Observatory, Surveyor General's Office, Calcutta.

TABLE IV.

Date.	Hour.	Barometer.	Attached Thermometer.	Detached Thermometer.	North End of Needle.	South End of Needle.	Mean.
1829.	H. M.	Inches.	°	°			° ′ ″
May 23d	0 25 P. M.	29·220	95·8	90·0	2° 07′ 40″	2° 08′ 30″	2 08 05·0
	4 43	·768	85·5	85·0	2 08 25	2 10 15	2 09 20·0
24th	9 15 A. M.	·862	88·8	88·8	2 08 40	2 12 40	2 10 40·0
	0 15 P. M.	·780	92·8	94·5	2 04 25	2 11 15	2 07 50·0
25th	9 25 A. M.	·770	90·0	90·6	2 06 40	2 10 40	2 08 40·0
	0 15 P. M.	·738	93·8	95·0	2 10 05	2 10 50	2 10 27·5
	4 30	·650	95·0	94·0	2 07 40	2 12 10	2 09 55·0
26th	9 05 A. M.	·740	89·7	90·3	2 12 25	2 14 45	2 13 35·0
	0 30 P. M.	·686	95·0	96·0	2 07 05	2 10 45	2 08 55·0
	4 18	·604	93·5	93·5	2 09 30	2 14 40	2 12 05·0
27th	9 35 A. M.	·704	90·0	90·0	2 11 35	2 13 25	2 12 30·0
	0 25 P. M.	·636	93·7	94·0	2 07 30	2 11 15	2 09 22·5
	4 30	·560	94·4	93·4	2 10 10	2 13 00	2 11 35·0
28th	9 14 A. M.	·592	86·0	87·0	2 09 25	2 13 20	2 11 22·5
	0 30 P. M.	·548	97·0	97·5	2 07 10	2 08 20	2 07 45·0
	4 05	·530	90·0	90·0	2 11 40	2 16 10	2 13 55·0

Date.		Hour.			Barometer.	Attached Thermometer.	Detached Thermometer.	North End of Needle.			South End of Needle.			Mean.		
1829.		H.	M.		Inches.	°	°							°	′	″
May	29th	9	05	P. M.	29·622	88·5	86·8	2°	09′	40″	2°	11′	36″	2	10	37·5
		0	10		·588	90·5	91·5	2	06	20	2	08	55	2	07	37·5
	30th	9	45	A. M.	·622	87·3	88·0	2	08	35	2	10	55	2	09	45·0
		0	25	P. M.	·612	91·0	93·0	2	04	15	2	10	05	2	07	10·0
		4	15		·546	93·5	94·0	2	11	45	2	14	45	2	13	15·0
	31st	9	24	A. M.	·650	85·0	85·5	2	07	55	2	11	50	2	09	52·5
		0	17	P. M.	·636	85·5	90·0	2	07	30	2	12	10	2	09	50·0
June	1st	9	25	A. M.	·636	90·0	90·0	2	06	50	2	13	00	2	09	55·0
		0	35	P. M.	·610	91·3	91·8	2	02	20	2	06	50	2	04	35·0
		4	20		·530	94·0	94·5	2	04	40	2	10	45	2	07	42·5
	2d	9	15	A. M.	·540	88·5	89·5	2	08	50	2	12	15	2	10	32·5
		0	17	P. M.	·530	94·5	95·5	2	06	25	2	08	40	2	07	32·5
		4	20		·462	100·0	101·0	2	08	25	2	13	30	2	10	57·5
	3d	9	50	A. M.	·508	86·0	87·0	2	08	00	2	12	40	2	10	20·0
		0	20	P. M.	·504	91·5	92·5	2	05	00	2	10	00	2	07	30·0
		4	18		·420	92·5	92·5	2	04	25	2	09	35	2	07	00·0
	4th	9	30	A. M.	·490	92·0	93·0	2	08	00	2	11	15	2	09	37·5
		0	20	P. M	·470	95·5	95·5	2	05	35	2	10	10	2	07	52·5
	5th	9	45	A. M.	·488	93·0	91·0	2	04	30	2	12	45	2	09	07·5
		4	20	P. M.	·414	100·0	100·5	2	12	10	2	18	10	2	15	10·0
	6th	0	17		·530	96·0	97·0	2	05	30	2	12	30	2	09	00·0
	7th	9	10	A. M.	·670	87·0	88·0	2	11	35	2	16	20	2	13	57·5
		0	14	P. M.	·676	92·5	93·5	2	08	35	2	13	15	2	10	55·0
	8th	9	35	A. M.	·730	91·0	92·0	2	12	25	2	14	45	2	13	35·0
		0	25	P. M.	·728	96·0	97·0	2	05	20	2	08	50	2	07	05·0
	9th	9	25	A. M.	·792	90·5	91·0	2	08	05	2	14	00	2	11	02·5
		0	15	P. M.	·778	95·0	96·0	2	03	40	2	08	05	2	05	52·5
		4	20		·708	100·0	101·5	2	04	05	2	08	40	2	06	22·5

Needle, East of the true Meridian, ...	2°	09′	46″	Mean.
Add correction for Zero of Compass Box, ...		14	24	
True Declination, Easterly, ...	2	24	10	

II.

ON A SPECIES OF
AQUILA, CIRCÆETUS,
AND
DICRURUS.

BY MR. HODGSON.

I.

ORDER Raptores. Family Falconidæ, Stirps Aquilina. Genus Aquila. Species new?

This noble bird, though not, by any means, the first, is yet *among* the first, of the Eagle Race, being fully two feet eight inches long, and six and a half feet wide, with weight, strength, and vigor in proportion.

Above or along the ridge, the bill is, so far as the cere extends, nearly straight, and also slightly flattened or depressed; beyond the cere, it is (still above) sloped into the hook, and also acutely rounded. The bill is rather longer than the head, with a wide gape cleft beyond the centre of the eye.

At the gape it has great breadth which rapidly diminishes towards the hook; but still the lateral compression is no where more than slight, so that the sides of the bill have throughout a considerable convexity. The inner margins of the bill are entire. The lower mandible is rounded beneath, and slightly and obliquely truncated at its tip.

The cere is large. The fore angle of the eye is the focus of a set of hairs which thence diverge, chiefly forwards, covering the cere as far as the nostrils exclusively. The rest of the cere is naked.

There are a few hairs under the lower mandible: none at the gape. The nostrils are placed very forward in the cere. They are cleft transversely and near to the perpendicular: in shape, like the outer margin of the human ear, which form I suppose to be that styled *lunation* by Zoologists.

The eyes have a strong brow, from under the shade of which they glance terrifically.

The tarsi are short, very strong, and feathered to the toes. The toes are of moderate length, unequal, stout, reticulated, with two or three large scales at the roots of the talons. The talons are exceedingly strong, large, much hooked, moderately acute, flat within, and unequal, the hind one, and internal fore one being much larger than the central fore one, and still more so than the external fore one.

The wings are long, reaching within three inches of the end of a tail that is upwards of a foot long. The great quills are strongly emarginated within—fourth quill longest The tail is moderate, even, consisting of twelve nearly equal feathers. The feathers of the head and neck are narrow and pointed ; and many other of the body feathers tend to a pointed form.

The colour is, *superficially*, of an uniform very pale brown with the great feathers—such as the largest scapulars, the quills, and tail feathers —uniform dark purpurescent brown. Upon a closer view, however, it is found that the great feathers above noted, are paled nearly to white at their extremities, especially the upper extremities, and chiefly on their internal surface—that in some of the secondary quills the brown and white are mixed in the marble-fashion—and that in some again the dark color appears in the shape of regular cross bars, particularly on the inner webs of the feathers.

The down at the roots of the feathers is every where white ; and the shafts of the feathers are white near their roots ; elsewhere colored like the webs.

The greater internal wing coverts are pure white, and the tail coverts (especially the internal ones) nearly so.

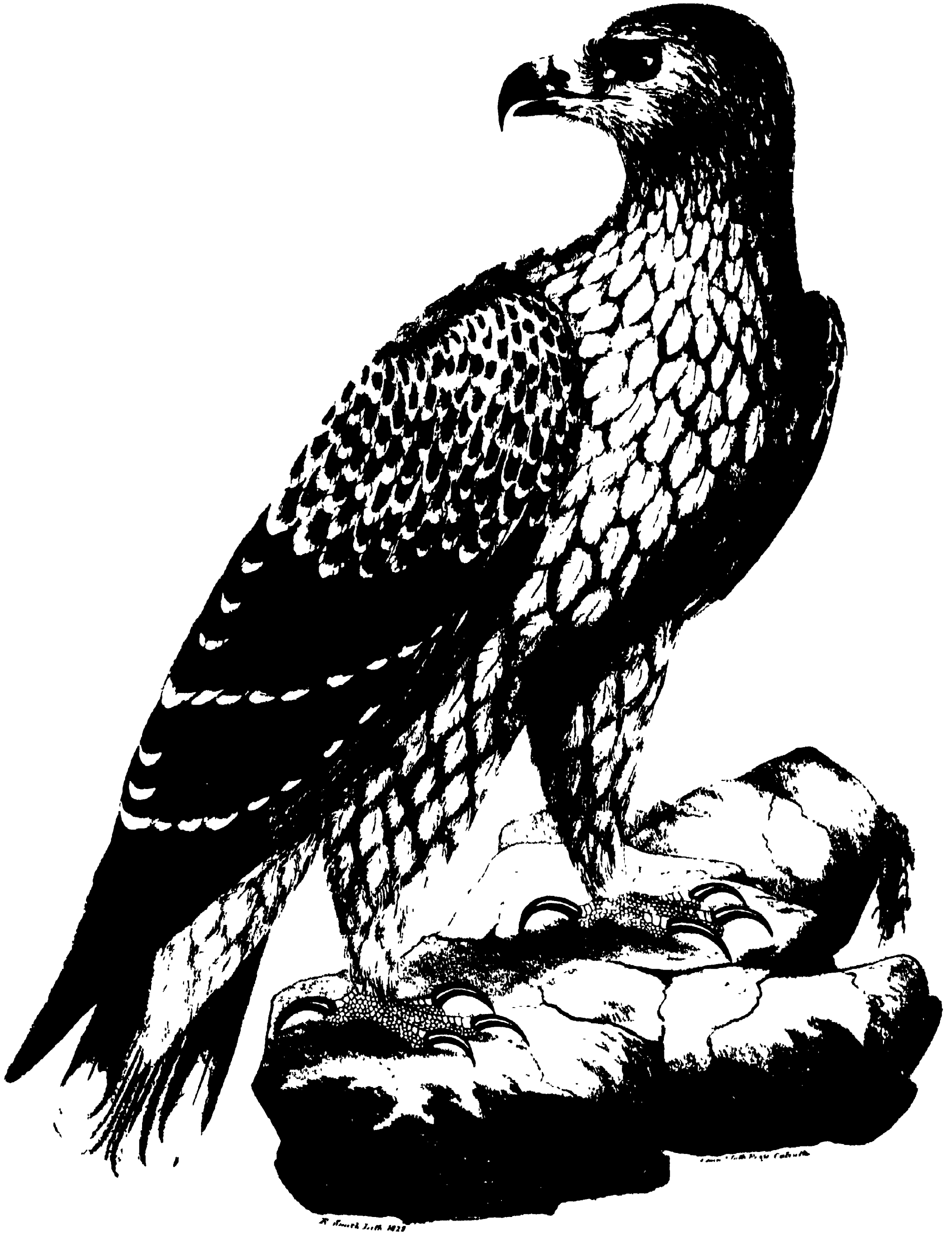
The toes are yellow—the talons black—the cere and gape yellow, with a slight greenish admixture—the bill blue-black, with its basal parts paler and blue—irides, brown.

This species of Eagle inhabits that part of these mountains which is equally removed from the vast Himálaya on one hand, and the small hills, confining the plains of India, on the other. It is often seen in the great valley of Nepàl, and the sole specimen I have been able to procure, was obtained there. Its manners are unknown to me.

I have no doubt that the bird above described belongs to the genus Aquila of Vigors (Apud SHAW'S Zoology, XIII. 2, 15.) and I suppose that the slight depression of the ridge of the upper mandible of its bill towards the base is what that writer means by the "beak somewhat angular above" of his generic character. But "nostrils *rounded*" of the same character much less accurately describes the nostrils of our bird, than the equally short and technical term "lunated"—to which, however, I have preferred the comparison to the external rim or outline of the human ear.

Whilst I notice this deviation from the generic character as laid down by the work I have followed, I may add, that I conceive it to be unimportant, and that the bird unquestionably belongs to the genus Aquila. The species is probably new; since it is not to be found among the nine described in the vast and recent work already frequently alluded to. The dimensions and weight of our bird are as follow:

	Feet.	*Inches.*
Tip of bill to tip of tail,	2	8
Bill,	0	3⅛
Tail,	1	0¼
Leg, from hip to point of central claw,	1	2
Tarsi,	0	4
Central toe and claw (in straight line).	0	3⅜
Hind claw,	0	1⅝
A closed wing,	1	11
Expanse of wings,	6	5¾
Weight,	7 lbs.	



R. Smith Lith 1828

[illegible] Lith Press Calcutta

AQUILA NIPALENSIS

II.

ORDER Raptores. Family Falconidœ. Stirps Aquilina. Genus Circæëtus? Species new?

This compact, powerful, and well-proportioned bird, though considerably less than the true Eagle, just described, is yet more nearly akin in size (as in other respects,) to the aquiline stirps of the family of the Falconidæ, than to any other stirps of that family.

Having only the very slightest acquaintance with its manners, I am doubtful amid its slightly-marked characteristics as to its proper genus. But I shall endeavour to give so accurate a description of it as to leave no room for doubt in the minds of persons more versant with Zoology than myself.

In SHAW, vol. VII. p. 157, pl. 22, a bird called Falco Bacha, is described and figured. The bird now before us bears a marvellous resemblance to that bird in the colors of its plumage, in the shape and size of its crest, and even in its general figure and proportions. But as our bird is vastly larger than the *Bacha* and as that bird is ranged in SHAW's XIIIth vol. under the genus Cymindis, scarcely any of the characters of which genus suit our bird, I have no doubt it must be distinct from the *Bacha*, and not finding it any where in SHAW's great work, I venture to describe it as what is probably new. The bill is as long as the head, scarcely cleft beyond the fore angle of the eye, and of less than moderate width at the gape. Its lateral compression is considerable, so that the ridge of the bill is acutely rounded and the sides of it have hardly any convexity. Beneath, it is obtusely rounded. Considerably beyond the cere, the bill, *above*, is straight ; thence forward, regularly and gradually sloped into the curve of the hook—which latter is large and acutely pointed. The lower mandible is rounded beneath ; and obtusely pointed, or, I should rather say, obliquely truncated, at its tip. The inner margins of the bill are entire. The orbits and space between the eye and the bill are naked, save a partial covering of harsh hairs, or bristles, which diverging from the fore angle of the eye, tend chiefly forwards, partially clothing the sides of the cere and curling upwards above the top of it. About the gape and lower mandible likewise are some scattered bristles. The nostrils are obliquely cleft, open, and of an irregular oval shape. The wings are long rather than moderate, and extend to less than three inches of the end of the tail, which is rather more than a foot long. They have the fourth quill longest, but the fifth almost as long ; and the largest quills are slightly emarginated.

The tail is moderate, well rounded, consisting of twelve feathers. The tarsi are long, naked, reticulated, with the reticulation coarse. The toes are short, thick and fleshy, or *gummy;* the outer connected at the base to the middle one, as far as the first joint The toes are, besides, unequal ; for though the lateral fores are nearly of equal *length*, the inner is *stouter* than the outer lateral, or even than the central one. The talons are stout and of fair, but not remarkable length, curvature, and acuteness. The hind talon and inner fore one are the largest, and are of equal size. The central one is as long but not so stout as they are: the inner fore claw, considerably smaller and shorter. The talons are flat within. The above description tallies essentially, as it appears to me, with SHAW's generic character of the Circæëtus, with the single exception of " nostrils lunated"—this bird's nostrils being, *rather at least*, irregularly oval.

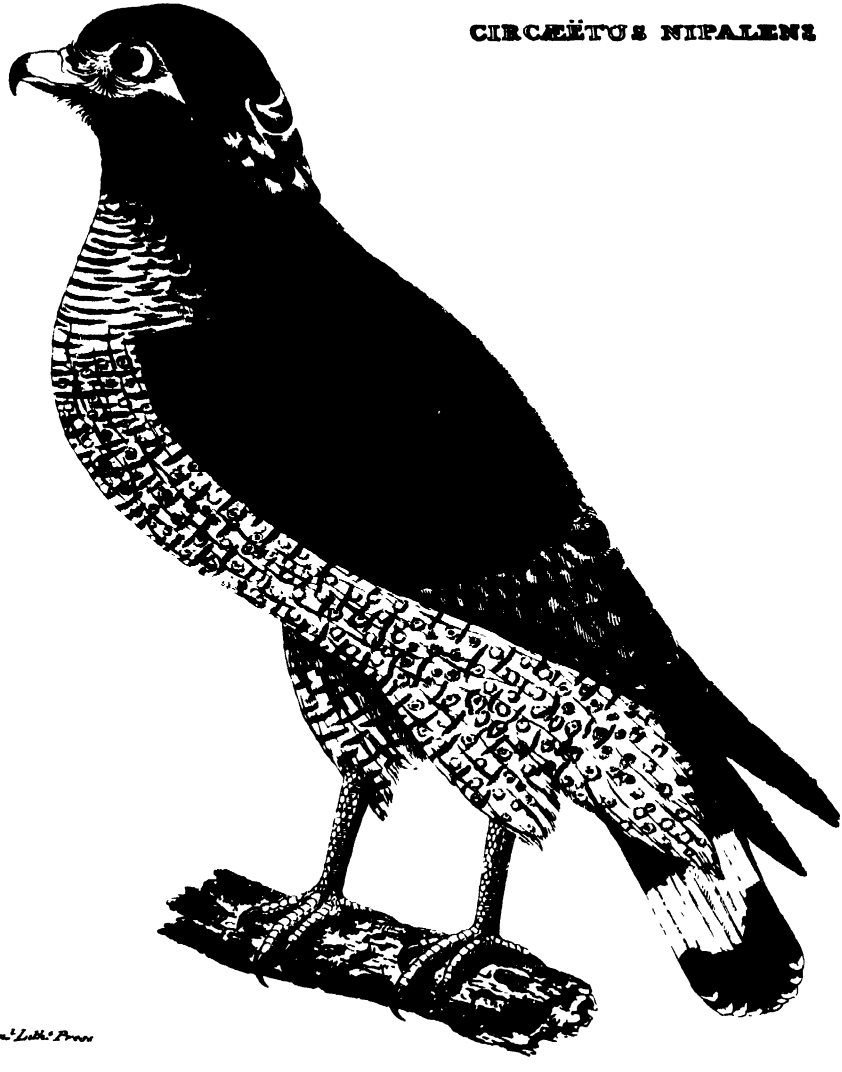
The back part of the head is furnished with a few feathers of similar texture with the others, but somewhat elongated, and forming a sort of pendant crest. The feathers upon the body beneath are long, and have long discomposed webs. Such also are the thigh feathers. The rest of the plumes have no peculiarity. Most of them have ample webs and broad terminations. The top of the head and nape and crest are clothed with feathers, which are black from their tips nearly to their centres, white from their centres to their roots; and as the crest, though usually pendant, is slightly erigible, when erected, a small portion of the white part of the feathers is revealed and shows like a cross bar of white on the crest. The rest of the plumes on the bird's upper surface are of a dark purpurescent brown, which is darkest upon the lesser wing coverts, great scapulars, quills, and tail feathers. Most of the quills and tail feathers and upper tail coverts are tipped with white; and the little wing coverts are doubly dotted with white near their tips. Upon the wings and tail is one broad distinct transverse bar, running entirely through them. Above this bar, there is another, parallel to it, on the great quills; and something like this second bar may be also brokenly traced along the secondary quills, as well as on the tail feathers. These bars shew whitey-brown upon the superior surface of the quills—pure white on their interior surface. Upon the tail feathers, the lower and decided bar shews equally and fully white on *both* surfaces—but the upper and less distinct bar of the tail appears whitey-brown above, as is the case with the bars on the wings. Passing now down the inferior surface of the bird's body we note, first of all, that the eye-lashes, and bristles covering the sides of the cere, are black: the throat, black-brown: the neck, same as above, but paler: the breast, belly, thighs, and tail-coverts, pale dirty brownish-yellow with either ocellations or bars, of pure white, edged with clear brown, disposed cross-wise down either side of each feather: the lesser wing-coverts, the same, but with a paler ground colour: the greater coverts, regularly and equally crossed with white and black-brown throughout: irides, *orange* yellow: cere and orbits, and naked space between the eye and the bill, full *clear* yellow; bill, leaden-blue, with a black hook: legs, obscure dirty yellow: habitat, same as the preceding.

This species is said by the Nipalese to feed on fish. I myself have seen it frequently perched on rocks and trees, overlooking streams that were full of fish. But I never saw it attempt to catch them. I have seen it seize pigeons, and one of my specimens had a small innocuous kind of snake taken out of his throat after he was killed. It ordinarily soars very high: and the male and female are almost constantly together. The female differs from the male chiefly, in having a smaller crest and less full bodied colours Proportions, size, and weight as follows:

	Feet.	*Inches.*
Tip of bill to ditto of tail,	2	5¼
Bill,	0	1⅞
Tail,	1	0
A closed wing,	1	6½
Total leg (as before,)	0	11
Tarsus,	0	4¼
Central toe and talon,	0	2¾

Weight 4 & ¾ lbs

CIRCÆËTUS NIPALENS



Comml. Lithc. Press

THE **BHÚCHÀNG** AS LARGE
AS LIFE.
Dicrurus Indicus (W. Mac)

III.

ORDER Insessores. Tribe Dentirostres. Family Laniidæ Genus Dicrurus.

Dicrurus cœrulescens ?
Di. œratus ?
Di. Indicus ?
} SHAW, 13. 137. 8. 9.
Do. 7. 291. &c.

Bill rather longer than the head, very smooth, stout, nearly straight, at the gape broader considerably than high, base clothed with short quasi-setaceous feathers, and stout bristles, pointing forward and outwards: both mandibles with their sides rounded and tips acute; *upper* mandible somewhat sharpened above or along the ridge; its edges somewhat overlaying those of the lower one; slightly dentated and hooked at the tip: *lower* mandible, rather flattened beneath, slightly emarginate and recurved at the tip. *Gape* rather wide, and furnished with bristles. *Nostrils* round, lateral, basal, partially concealed by short quasi-setaceous feathers. *Legs* rather short: four toes, three before, one behind; central toe and claw equal to tarsi; outer fore toe not quite so far cleft as inner; hind toe and claw stouter than central fore ones: *claws* very sharp and hooked.

Wings long and acuminated. Fourth quill longest; first very insignificant. *Tongue* flat, of moderate length, near the tip cartilaginous and jagged, tip forked. *Tail* very long and conspicuously forked; consisting of ten feathers disposed in pairs, whereof the uppermost pair are shortest, and lowest longest by one and a half inch; intermediate ones regularly graduated in length.

The *full-grown male* bird measures from tip of bill to tip of tail upwards of twelve inches, whereof the tail to its roots, is seven. The expanse of the wings is seventeen inches : when closed, and measured from shoulder-tip to point of longest quill, the length is nine inches. Bill to gape, is more than an inch long. The weight of the grown male is 1 oz. 7 or 8 dr. The head and bill are somewhat large, but not disproportionately so ; and these parts, as well as the tongue and legs, have an extremely corvine character. Except an oval spot of pure white on each side the gape, the plumage is entirely black, richly glossed with deep blue, which sometimes shews green, especially on the wings and tail. The inner webs above, and whole inferior surfaces of the wings and tail are unglossed—every where else the gloss prevails. The bill and legs are pure black : the irides red brown.

The female is nearly as large as the male. She differs from him in not being so deeply coloured and glossed above; and, in having the upper and under tail coverts, the internal wing coverts, the sides of the body, the breast, abdomen, and vent, spotted and shaded with white.

The spots are very distinct on the inner wing coverts ; and the tail-coverts have their tips distinctly white ; but upon the body beneath the white is blended with the black, so as to form an iron-grey colour. The thighs of the female are immaculate black, like those of the male.

The young birds for some time resemble the female in plumage and even after they are fully grown, the young males long continue to shew more or less of white on their plumes, especially on the tail coverts. A spot of white is often seen on their breasts, and often on the tips of the tail feathers.

From a careful examination of several of these birds—males and females—young and old, I am led to suspect that the three species in Shaw, referred to above, are only more or less accurate descriptions of one and the same species. The Laniidæ of this work exhibit—according to Stephens' new arrangement—a world of genera separated, I humbly think, with more cunning than wisdom. But be that as it may, I trust that the accurate details now furnished from ample observations, will enable the future Ornithologist at least to give an accurate and full account of the Indian *Bhúchàng*, and to determine whether Shaw's three species be really distinct or not.

The bird is found very generally throughout the vast Bengal presidency, and also in the mountains confining it on the east and north. It is very common in the valley of Nipal; is familiar with man; and seems to love the neighbourhood of country houses.

It is monogamous, and associates usually in pairs—but five or six are always found in the same vicinity. It is capable of a very rapid forward flight, and when exerting its speed makes a loud whirring noise with its wings. Commonly it makes short jerking parabolic flights from and to a bare tree, whereon it sits watching for insects and thence darts, as above described, to catch them on the wing. I have been told it will sometimes seize very small or young sickly birds—but never saw it do so: and its food undoubtedly consists, in the main, of insects, and chiefly of winged ones. It likewise feeds upon the vermin that harboür in the skins of sheep and oxen; and is constantly seen attendant upon herds and flocks, perched upon an animal's back, and searching the skin with its bill.

It is very bold, frequently pursuing Crows and Kites, that come near its perch—and such is the rapidity of its flight that it can overtake the

Kite when he uses his best efforts to outfly it. When up with him it darts at his head continually from above—but never—so far as I have seen, actually strikes him. All birds seem afraid of it, and it of none. It is very vivacious, darting about all day, and all night too, when the moon shines. It seems to love dawn, twilight, and moonlight; and at such times especially continually utters (one bird responsively to another) its agreeable whistling note of two prolonged syllables, which the Hindoostanies fancy they can frame into *Bhúchàng*; the Bengalees, into *Phingah*—and by those names accordingly, the bird is known to them respectively. Strange but true, its note is more pleasing than that of the vulgar Indian *Bulbul!*

It nidificates early in June, in the branches of trees, making its nest neatly of small grass roots, and laying usually two or three eggs, which are white, spotted with deep crimson, especially at the broad end. Both sexes tend the young, and most assiduously feed and defend them.

There is another Shrike found in the Nipaulese Terái and mountains, and also in the great valley of Nipal, which bears a strong general —but not particular—resemblance to the one above described—but having already stated that the diagnostics of the modern genera of the Laniidæ, are to my eyes very indistinct, I shall not attempt to assign its genus— but briefly describe it by comparison with the foregone.

It differs in having the upper mandible of the bill laterally compressed, and also much more strongly dentated and hooked—in having the tail even at the end and the uppermost pair of feathers longest, the lowest pair, shortest; and in having twelve, instead of ten feathers, in the tail— and lastly, in having the shoulders of the wings united in a nearly straight line to the body from the second joint instead of descending in an acute angle towards the first joint.

To these differences I should add that the tarsi are rather longer and smoother than in the foregone.

The plumage too is totally different, and is as follows. The top of the head, dorsal neck, upper part of the back, and scapulars (besides having looser and more elongated webs than in the foregone) are slaty blue. A broad line of perfect black passes round the base of the upper mandible through the eyes to the sides of the neck. The throat, cheeks below the eyes, and centre of the breast and belly, thighs, internal wing coverts, and inner margins of the quills, on their internal surface, white.

The sides of breast and belly, and the lower part of the back, the upper and under tail coverts, and outer margins of the lateral tail feathers near the body, are pale clear ferruginous—the wings and tail dusky, the former with the outer margins of all the feathers, but the great quills longitudinally striped with rufescent white, and the latter with all its feathers tipped with the same colour.

This bird is also somewhat smaller than the other, measuring only in extreme length nine and half inches, whereof the tail, to the roots, is five inches. The tail therefore is as long in proportion as in the foregone; and it must be obvious from the above description of it that, when slightly expanded, it is wedge-shaped. The irides are dull brown: the legs and bill are black, as in the foregone; and I need hardly add—having already asserted the general resemblance of the birds—that the bill, tongue, nostrils, legs, wings, and tail, are alike in form and proportions, saving the difference specifically noted.

This bird is much rarer and shyer than the other, and I have had no sufficient opportunities of observing its manners.

The female of this species is rather less than the male. Her colours are all duller. She wants the black zone round the base of the upper mandible of the bill. Her breast and sides of her body are crossed with small crescents of a faint dusky hue: and the *base* of her bill is paled nearly to fleshy white. In all other points she resembles her mate.

Valley of Nepál, June, 1829.

III.

SKETCH

OF THE

GEOLOGY OF CENTRAL INDIA,

EXCLUSIVE OF MALWA.

By JAMES HARDIE, Esq.

READ THE 8th OF APRIL, 1829.

In the following Communications I have endeavoured to convey a general idea of the Geology of Central India, in the hope that, as opportunities occur, I shall be enabled to fil up the slight sketch now offered, by minuter descriptions of individual portions of this extensive tract of country.

Nomenclature adopted in this paper.—Before describing the rocks of this district, it will be as well, to prevent confusion, that I should explain the nomenclature which I have adopted.—A looseness in this respect has been an endless source of confusion in the science of Geology, many different names being applied to the same rock by different observers, and it is greatly to be wished that some specific plan should be had recourse to. As the case now stands, I shall simply endeavour to make myself understood.

I propose including all the rocks which occur in this district under the following heads, viz:

Granitic rocks,
Gneiss,
Quartz rocks,
Micaceous schist,
Chlorite ditto,
Talcose ditto,
Argillaceous,
Hornblende rocks,
Greenstone,

Serpentine, Marble, and Porphyry.

Under the head granitic rocks shall be included those only which have not a slaty structure, and which are composed of *two* or more of the following ingredients; viz. quartz, mica, felspar, cleavlandite, hornblende, and occasionally steatite, talc, and chlorite. The only exception to this rule will be found in some varieties of rocks, in which hornblende preponderates, and which shall be placed under the head "hornblende rocks."

Stratified, as well as *unstratified*, rocks, shall be included with the granites, as every one who has visited this district must allow that distinct and well-marked granite does occur in strata; and I am compelled to state this in opposition to the high authorities of Macculloch and Phillips. Mr. Phillips allows (see Outlines of Geology, p. 164,) that granite is sometimes found disposed "in beds which possess *the ordinary characters* of *stratification*," and Dr. Macculloch, in support of his opinion, (see Journal of Sciences and Arts) is obliged to account for the adduced instances of stratification in this rock, by declaring that "they may all be referred to laminar concretionary structure on the large scale,"—or that the instances alluded to are "portions of gneiss of which the structure so often becomes *perfectly granitic*,' or lastly, that they are "veins of granite traversing the gneiss in directions parallel to the strata." I trust I shall be excused if, in describing gneiss which perfectly resembles granite, I shall include it with the granitic rocks. Their constituents are exactly the same, and the distinction does not appear to me very clear or obvious. In as far as this district is concerned, the Wernerian School, at the head of which deservedly stands Jameson, is certainly in the right, and the name and authority of this distinguished Geologist will excuse what might otherwise have been deemed presumption in me, in thus stating my opinion in opposition to the authorities before alluded to

There are a number of rocks in this district composed of two ingredients, generally quartz and felspar. These most frequently are found stratified—to class them with the porphyries, therefore, might lead to confusion, and this latter term shall be applied to those only which are *not stratified*, and which have a distinct porphyritic structure. Indeed this rock, so understood, is of very rare occurrence in this portion of India.—Besides, the rocks under consideration do not resemble the porphyries, on the contrary, they agree in every respect with the granites; and all things considered, I think it advisable to class them with the granitic rocks—such a classification is in exact accordance with Dr. Macculloch's definition of granite, which definition I have adopted; and I have only added to his list of constituents "*cleavlandite*,' which, according to Phillips, is of universal occurrence in rocks of this class. I cannot say that I am possessed of any correct method of distinguishing cleavlandite from felspar. Indeed the only method I know is that of analysis—an analysis which, with my limited apparatus, I find it difficult to conduct—I have frequently, however, observed what I have been in the habit of considering as two distinct varieties of felspar in different granitic rocks, and I have no doubt but that one of these is the cleavlandite.

In describing the various individuals of this class, different adjuncts, illustrative of their composition, shall be used, and in this view of the case, the granitic rocks may be divided into the following varieties:

First.—Granites composed of three ingredients.

A.—Common Granite—composed of quartz, felspar, and mica.
B.—Sienitic Granite—composed of quartz, felspar, and hornblende.
C.—Talcose Granite—composed of quartz, felspar, and talc or steatite.
D.—Chloritic Granite—in which chlorite replaces the mica.

Second.—Composed of *four* or more ingredients.

A.—Micaceous Sienitic Granite—Sienitic granite, with the addition of mica.

B.—Talco Sienitic Granite—the same as the above, the mica being replaced by talc or steatite, &c. &c. &c.

Third.—Granites composed of *two* ingredients.

Under this head shall be included rocks, which might perhaps be classed with the compact and granular felspars. The term *white stone*, applied to the latter by Werner, is not well adapted for this rock, as it frequently occurs in this district.—Names derived from color, are always objectionable, and, as this rock is here found more frequently of a redish color than of any other, I prefer giving it the name of granite, more especially as some other ingredient is almost universally associated with the felspar, whether compact or granular, and these pass into, and are intimately connected with, the granites—when they occur pure, the circumstance shall be mentioned. I do not feel myself called upon, or at all qualified to give a particular name to this class of rocks, and in describing them, I shall merely state their composition; as for instance, "a granitic rock composed principally of reddish colored felspar, with minute scales of mica interspersed through its substance"—stating the relative proportions of the ingredients to each other, &c. &c. Several rocks composed of felspar and quartz, and which were alluded to above, shall also be placed under this head, and these are either large or small grained, &c. The term granitic porphyry might, perhaps, be applied to the latter.

GNEISS.—Gneiss, as it commonly occurs, requires no definition, and the only other varieties which I have observed in this district are—*First.* A gneiss in which the mica is replaced by hornblende, and to which I have applied the name of *sienitic gniess*:—and *Second.* A gniess in which the mica appears to be replaced by chlorite. To this last, the term *chloritic gniess* may be applied.

QUARTZ ROCK.—I have, perhaps, placed a greater variety of rocks under this head than I ought to have done. The immense beds of quartz rock, however, which present themselves in this district, form a very striking feature in its Geology. From the pure white semi-transparent quartz, to the more slaty varieties, where it passes into micaceous and argillaceous schists, there is a regular gradation observed, and I cannot help thinking, that one general name ought to be applied to the whole series. It occurs either stratified or unstratified. The former, perhaps, where it passes into the argillaceous schists, ought to be named flinty slate. I prefer, however, retaining the name of quartz rock, as the other might lead us to confound it with a more recent formation, in which the flinty structure, as commonly understood, is a characteristic feature. When any individual of this class passes into any particular rock, the circumstance shall be mentioned, while the more compact varieties of argillaceous schist shall be named siliceo-argillaceous schists. The term primitive sandstone, adopted by DR. MACCULLOCH, I have not made use of, from a similar objection to that stated above regarding the name, flinty slate. I shall simply describe the different varieties of quartz rock as they occur, stating their color, structure, &c.—and under this head, I shall include all those apparently simple rocks, which are principally composed of silica. Small proportions of other ingredients may be associated with this, but the name quartz shall be retained as long as they preserve an *apparently homogenous structure.*—Quartz rock, as I have before stated, of almost every variety of structure, occurs in this district, associated with all kinds of rocks, such as micaceous and argillaceous schist, granite, &c. In all these it occurs pure, and is also seen passing into them, and acquiring different shades of color from intermixture. This circumstance alone presents a great objection to the division of the rocks of this district into submedial and inferior orders.

Hornstone, is a name applied by Captain DANGERFIELD* to many of the quartz rocks of this district:—this name might lead us to confound them with the hornstones of the trap formation, with which they have nothing in common. Besides, he has given this name to two rocks of very distinct and different series; viz. to a rock associated with those of a decidedly old class, and to another, which overlies the sandstones and sandstone slates of the north of *Malwa*. The latter is universally associated with a breccia, contains iron ore in large quantities, and sometimes assumes the appearance of a nearly pure or ferruginous quartz rock. Mr. PHILLIPS, in describing primitive sandstone, which he classes with the "inferior rocks," says (p. 158, Outlines of Geology,) that "detached fragments of gneiss and clay slate occur in it," the clay slates are classed with the "submedial rocks." In this case, however, the clay slates must be of more ancient formation than the primitive sandstones, on which they are found imbedded—Another strong objection to his classification.

---

* Since writing the above, I have heard with sincere regret, that this Scientific Officer is no more—and I cannot resist the opportunity of paying my humble tribute of admiration to his memory. We cannot be too grateful to him for the light he has thrown on the Geology of Central India, at a time, too, when Geological Science was less understood and less cultivated than at the present day; and in this expression of my individual feelings I know I shall be joined by all who take the least interest in scientific pursuits. The rough copy of this paper was drawn out before the melancholy intelligence reached me, and I have not deemed it necessary to make any alteration n it, as to substitute the *past* for the *present* tense. In a climate like this, how short the space which separates life from the grave.

MICACEOUS, TALCOSE and CHLORITIC SCHISTS.—These require no definition—they are found passing into. and alternating with each other, and into other rocks.

ARGILLACEOUS SCHIST.—This name, adopted by Dr. MACCULLOCH, from the French, appears to me ap' and comprehensive, and by it I mean to indicate all those rocks which are usually included under the heads "clay slate" and "grey wacke slate." Many of the argillaceous schists of this district approach to the nature of grey wacke slate, as commonly described. The transition from the one to the other, however, is so gradual, that the more I have seen of these rocks, the more I have been convinced that one general name ought to be applied to the whole. The nature of each variety of argillaceous schist will, of course, be described, and different adjuncts derived from their external characters, &c., made use of; such as—micaceous, talcose, chloritic, siliceo, argillaceous, wackaceous, friable, sectile, &c., and when they approach to, or pass into, any particular rock, this also will be mentioned.

HORNBLENDE ROCKS.—This will include hornblende rock and hornblende slate. Some of the varieties of hornblende rock might be included with the granites composed of *two* ingredients, such an arrangement, however, would separate them from the pure hornblende rock as well as from the hornblende slates, with both of which they are intimately connected. and would only lead to confusion. All rocks, therefore, in which hornblende preponderates, shall be placed under this head.

GREENSTONES.—Including greenstones and greenstone slates, or schists. Under this head will be placed only those rocks which *resemble the greenstones of the overlying trap formation*, and which have a more homogeneous and earthy aspect than the hornblende rocks. The more distinct varieties of greenstone slate only shall be included in this class—the more indistinct with the argillaceous schists—the phrase approaching to greenstone slate being prefixed.

SERPENTINE.—This requires no definition. Mr. PHILLIPS states, that serpentine, which he classes with the submedial rocks, occurs also associated with gneiss and mica slate.

MARBLE.—This will include primitive limestone and primitive dolomite —with these mica, and occasionally other ingredients, may be associated.

PORPHYRY.—I have before stated that this name shall be applied only to the well-marked varieties of this rock which occur *unstratified*. Indeed the porphyries of this district, may generally be classed with the granites, &c., in which case the term porphyritic shall be prefixed.

In the above I have only availed myself of names already in use, and I have avoided, as much as possible, having recourse to those endless distinctions, depending on minute shades of difference, which are more in the province of the Mineralogist than the Geologist. If I can succeed in making myself understood, it is all I hope for. In describing the newer classes of rocks, I shall endeavour to follow the arrangement of Conybeare and Phillips, an arrangement distinguished at once by its simplicity and accuracy; but, till the second part of their Geology of England appears, to which every Geologist must look forward as the future text-book of his studies, I must content myself with giving as minute a description of the rocks of this district as I can, so that any one who undertakes the task of drawing out a general Geology of India shall, I trust, be able, from these descriptions, to class and arrange the different rocks alluded to, after any system which he may chuse, and that the work which has been so ably begun by Mr. Calder, shall soon be finished.

In the above arrangement I have included only the rocks of the district in which I am placed, in as far as I have had an opportunity of examining them; but I by no means wish it to be understood from this that no other varieties of rock occur in the extensive tract under consideration.—Such an assertion, the opportunities I have had of examining it do not entitle me to make, and I shall reserve to myself the privilege of adding to the number when occasion shall require.

Probable limits of the primitive formation of Central India. —I shall now proceed to offer a few hints relative to limits of the great primitive formation under consideration —I am sorry that most of my remarks on this head are merely conjectural; I offer them, however, with the hope that they may prove useful to future observers, and that their correctness or incorrectness will soon be satisfactorily proved.

This tract, then, includes within its limits the northern part of *Guzerat*, the greater part of the district of *Bayur*—the districts of *Serúl*—*Mewar*—*Marwar*—*Ajmer*—and *Jaypur*—with, probably, portions

DANGERFIELD in MALCOLM's Central India. I have had but few opportunities of examining it; besides, to enter into particulars would be out of place in my present communication, and I may, perhaps, hereafter recur to the subject. I cannot refrain, however, from giving the following few particulars, as they may serve as hints to any one who may hereafter examine this formation.

Proceeding from *Udaypur* to *Nímach* directly east, we have a succession of primitive rocks till we reach *Nakúm*, a village about thirty-six miles west of the last-mentioned cantonment. At *Nakúm*, and for a short distance to its east, we have still primitive rocks, but embedded in these we observe the first indications of an approaching newer formation. The hills at *Nakúm*, which are craggy and precipitous, are composed of quartz rock of a white color, traversed by numerous seams and cracks, but which is nearly pure, and is arranged in strata conformable to the other primitive rocks of this district. In this quartz are small belts of a ferruginous variety of the same rock, of a dark yellow color, and approaching to the nature of jasper; and embedded in it. also in small quantity, is a quartzose conglomerate, which is the first indication we meet with in travelling east of a rock of this nature.—Alternating with the above, and in strata similarly arranged, is a rock composed of white quartz and red felspar, exhibiting a porphyritic structure, the basis being of felspar—some of the specimens present a partially conglomerate appearance. The general structure of the rock, however, is granular porphyritic; and in conformity with the arrangement which I have adopted, I must class it with the granitic rocks as a granitic porphyry.

Proceeding to the east of this formation, we have the surface generally covered with soil and vegetation, and numerous low rounded and conical hills are seen rising around us. The country, too, has a waved appearance different from the perfectly level plains of *Mewar*, and the hills rise less abruptly. On reaching *Bári*, thirteen miles west of *Nímach*, these hills increase in number, and a low range traverses the line of march. We have now got among rocks of a newer formation, which form a portion of the narrow belt above alluded to.

The lowest series of this belt consist of sandstones, sandstone slates, and a schist, which on one hand passes into sandstone slate, and on the other somewhat resembles the shales of the coal formation, and which passes into an argillaceous marl slate—the sandstones are, generally speaking, quartzose, fine grained, with an argillaceous, or ferrugino-argillaceous cement. The characteristic color of these sandstones is variegated —some are of a reddish color with white spots, and others are white or grey with reddish spots, while others again exhibit a zoned aspect. This rock is either compact, or passes through every variety of structure till it becomes nearly soft and friable. It is sometimes too, though rarely so, large grained, approaching to conglomerate.

The sandstone slates differ little from the above in point of color, but they have a distinct slaty structure, the slabs varying in thickness from two inches to quarter of an inch, and some of them may be even split into lamma as thin as common paste-board. Both of the above rocks, but more particularly the sandstone slates, are traversed in very many instances by numerous seams, running at right angles to the strata, and dividing the mass into a number of square and rectangular portions Mica is of very abundant occurrence on the sandstone slates, it is always of a grey color.

The shales and argillaceous marl slates, into which the last passes, are also of a variegated color At *Bári*, they are of a greenish grey color, sectile, with rather a greasy feel, fine grained, and containing minute scales of mica. They acquire a reddish ferruginous crust on exposure to the air. In other situations they are fawn-colored—in others whitish, or light buff, with streaks of a purplish color,—in others they approach to the nature of pipe-clay, with a distinct slaty structure—while in others they resemble a fine grained sandstone slate. In these we also observe the seams, above described, which run at right angles to the strata.

The above series of rocks occur in strata, generally slightly inclined to the S. E. and E. Sometimes, also, the strata are almost horizontal, while at others they exhibit appearances of a curved or saddle-shaped stratification. The hills are all low, and are topped by a rock hereafter to be described. Organic remains appear to be of very rare occurrence in this formation, and I have only met with one specimen from the neighbourhood of *Barí.* It occurred in a soft shale, somewhat resembling the shales of the coal measures. The specimen in question appeared to me, to be the impression of a portion of a cryptogamous plant. This plant appeared originally to have been expanded in a fan-like form, with ribs of about quarter of an inch in breadth, radiating from a common centre, the interior or central part of these being occupied by three or four longitudinal tubes. The diameter of this plant, or fan-like portion of a plant, might have been about five and half inches. The impression appears to have been covered with a thin bituminous crust, portions of which still remain. Except this, I have met with no other appearance of organic remains. Captain Dangerfield mentions the occurrence of impressions of ferns, in a fine-grained sandstone slate, at *Jiran,* and it is probable that the rock in which these occur is similar to the one just described.

With regard to the age of the above formation, I am inclined to believe with Captain Dangerfield, that it ought to be classed with the new red sandstones, (the red marl or ground of the English Geologists.) To the character of variegated, the sandstones, &c. are undoubtedly entitled, and the red ferruginous appearance of the soil, which is universally observed, is also characteristic of the above formation. Indeed the whole appearance of the rocks composing this series, is in exact accordance with that of the new red sandstones as described in Europe. The great characteristic of this formation is, however, as far as I know, wanting—I allude to the rock salt and gypsum, which are almost universally found associated with it. These certainly occur to our north, but a large primitive district intervenes, and the only indication which I have seen of salt is an efflorescence which occasionally appears at the surface, containing a large proportion of muriate of soda.* All things considered, however, I perfectly agree with Captain D. in classing these rocks with the new red sandstones, and I shall not be at all surprised, if future observations should discover them to be a continuation of the saliferous sandstone formation described by Captain FRANKLIN, and that they may be traced through the *Bharatpur* district, north towards *Dehli*, and may thus be connected with the rocks containing salt and gypsum, which must occur to the north of *Ajmer*, and be continued into *Lahore*, *Multan*, &c. south towards *Kutch*, extending, perhaps, even into *Persia*, and forming a zone around the great and elevated primitive formation of Central India, and separating it from the primitive formations of the *Himalaya* mountains. Traces of a formation, similar to the one above described, I have also noticed on the route from *Baroda* to *Udaypur*.

The very partial occurrence of organic remains on the above series of rocks, ought not to militate against the position I am endeavouring to establish. These are very rare, and besides it is not impossible that the shales in which these occur, may belong to an older class similar in position to the rocks of the north of Germany, (see CONYBEARE and PHILLIPS, page 311,) which overly the coal measures. I have never seen any traces of them in the well-marked sandstones or sandstone slates.

---

* See also Note to page 23.

Excepting in iron, the above series does not appear rich in metalliferous substances, neither have I met with any variety of simple minerals in it. I have occasionally seen, however, specimens of a fibrous variety of quartz disposed in small veins, or rather laminæ, interposed between the strata; and Captain D. mentions the occurrence of a "fat yellow clay," embedded in the sandstones.

The next rock which claims our attention in the above series, is the limestone on which this belt abounds, especially towards the north. I have little to add to the description of its external appearance, mode of occurrence, &c. as given by Captain DANGERFIELD; and, if I shall have occasion to differ from him respecting the age of this rock, I shall do so with all humility, fully aware as I am of the difficulties attending this branch of my subject. It is not improbable that two distinct varieties of limestone may occur in this belt, the one belonging to the mountain limestone formation, in which class Captain D. seems inclined to place all the calcareous rocks of the portion of the district under consideration; but the one which I am about to describe *overlies* the sandstones and sandstone slates, and I feel disposed to believe that it belongs to the lias formation. Perhaps, too, in addition to the above, there may be a formation of magnesian limestone of the English Geologists in the magnesia limestones described by Captain D. On this point, however, I can give no information, as I have only met with one variety characterised in every position, where I have had an opportunity of examining it, by a *similarity*, or rather *identity*, of *organic remains*. As I said before, however, the opportunities which I have enjoved of making observations on this belt, have been very limited.

These limestones, then, occur distinctly stratified. They are of a close texture, and of a dull color, generally greenish blue or lead grey—sometimes, too, they have a reddish tinge,—in other instances they are dirty white, while in one situation I have seen them of a brownish black color, and these latter emit a disagreeable smell on being rubbed. They *never occur variegated*, nor do they admit of a high polish, or of any depth of tint. On exposure, the surface acquires a duller aspect, and becomes slightly argillaceous. They are, generally speaking, compact, and many of them may be split into slabs of immense magnitude, varying in thickness from a few inches to a foot or a foot and a half. They form an excellent building stone, and are characterised by their *large conchoidal fracture* which passes, in many instances, into conchoidal splintry. These limestones sometime, though rarely so, are found larger grained. They occur in strata, generally slightly inclined in an easterly or south-easterly direction. Exceptions to this rule may here and there be observed ; but it is my object in this merely to give a general description of their mode of occurrence, without descending to minute particulars. The strata are very frequently separated from each other by thin layers of a loose calcareo-argillaceous substance, and nothing like the caverns, which usually distinguish the mountain limestone formation, can be observed in the rocks of this belt.

The ORGANIC REMAINS of these limestones are numerous ; but I am sorry that my limited information on this subject will not enable me to give as satisfactory an account of these as I could wish. Though a miserable Draftsman, I have endeavoured to represent one or two of the varieties, if possible, to render my descriptions more intelligible.

No. 1—May be considered as characteristic of this formation, and specimens, exhibiting the appearances attempted to be represented, are every where met with. On breaking a mass of this rock, we very generally observe that the surface presents the remains of what might have been a succession of cylindrical-convex,—probably solid bodies,—one fragment exhibiting these on a sort of baso-relievo, while the other presents corresponding hollows. These bodies taper to a point, and frequently occur minutely ramified at both extremities—this, at least, I have observed in several instances. They are perfectly mineralised, are of the same color as the mass, on which they appear generally as an incrustation. In one or two instances, however, I have observed the terminations of similar bodies on the mass itself, and in such cases they had obviously been arranged in bundles or fasciculi. In other instances, these cylindrical bodies appear to send off, anastomosing branches which unite them together. The latter may probably be a distinct variety. All of the above have a perfectly stony aspect, and I could discover on them nothing like a stellular structure, or any appearance of cells or pores. The length of these cylindrical bodies varies from about a foot to an inch or two inches—their breadth is also various, but they seldom occur broader than in the instance represented.

In one or two instances I have also observed longish tapering canals in the masses of limestone, which had obviously been occupied by cylindrical bodies. These, at the time of deposition of this rock, had either been detached from the bundles above alluded to, or had previously existed in a separate state. The latter I think the most probable. Could any of the above have formed the solid axis of any of the varieties of the lamellated polypifers? some of the detached specimens somewhat resemble the styliform axis of the genus stylina.

No. 2—Is also exceedingly common in these limestones, and I believe that at least two varieties of it may be traced,—probably, indeed, more. The one is a flattened, polymorphous, lobated, mass—sometimes seen covering the rock, over a square surface of a foot, or a foot and a half, and even more. No. 2 is detached, generally of the size represented, and it protrudes from the mass something in the form of a pear. It has a stalk like appendix.

The above remains occur protruding into the calcareo-argillaceous substance described as separating the strata. In the solid rock, the traces of them, if perceived at all, are very indistinct, a circumstance probably owing to the delicacy of their original structure. The rounded and lobated masses, indeed, appear to terminate abruptly on the side towards the solid strata, and their whole aspect gives rise to the belief, that during the deposition of these strata, short intervals occurred,—that the remains at their surface were left *partially exposed*, and that the inferior positions of these were lost in the solid rock, while their superior were, by this arrangement, more slowly impregnated with calcareous matter, which enabled them, on the deposition of the superjacent stratum, to retain something of their original form,—and that, in consequence of the delicacy of their structure, almost all traces of organization were destroyed. The interior of these remains presents, in many instances, a pure white crystalline mass, exactly similar to the finer varieties of primitive marble,—in other instances they have a loose, inclining to chalky, structure, and they are generally covered with a brownish crust, the centre being either pure white or dirty white, and rarely of the color of the limestone itself.

It is always exceedingly difficult to refer organic remains of this class to any particular genus. I am inclined to believe, however, that these form varieties of the alcyonium, and perhaps some of them ought to be classed with the sponges. In many of them I could trace appearances of a *cortical covering*, and in one or two instances, especially in those which occur detached, I think I could discover something like a *concentric laminar* structure. This appearance is only observed at their surface, and might have been occasioned by the original animal having had a cortical covering—*nothing like fibres* could be perceived;—the above circumstance, however, inclines me to include them in the class alcyonium.

No. 3—Is occasionally met with, but is not so common as either of the two preceding. The accompanying sketch will give a pretty correct idea of the remains of this kind, both as to their size, form, and mode of occurrence in the limestone. They occur, then, in the solid rock,—are perfectly mineralised, and are of the same color as the limestone. In specimens where this limestone has a structure inclining to granular, the remains of this kind exhibit a closer and more compact texture than the surrounding matrix. They appear to have formed the ribs of some animal, probably of aquatic origin. The vertebral extremity is flattened about seven-eighths of an inch in breadth, and the whole is slightly curved, and tapers to a point. The pointed sternal extremity does not seem to exhibit an articulating surface. It is thicker than the vertebral extremity, and a sharp spine runs from the point of about two inches in length, from which spine the bone had sloped on either side.

The only other organic remain which I have observed, is a shell; but in so imperfect a state, that I cannot decidedly say under what genus it ought to be included. It had obviously been a bivalved shell; but little except the margin of one of the valves remains, and I can only state the following particulars; viz. that it belonged to an apparently nearly equilateral bivalve of a roundish form, about three inches and a half in width. That this bivalve was convex, inclining to flat, and that it was longitudinally rayed, the rays being convex, broadish, and striated longitudinally. The hinge portion of this shell was wanting. It appears to have had considerable thickness and strength, and in all probability belonged to a variety of Pecten. The number of rays could not be correctly ascertained: their breadth was about two-eighths of an inch.

The above is all the information which I can give relative to the organic remains of these limestones, as I have, as yet, met with none other, except, indeed, the impression of what every one who saw it, believed to have been that of a small flattish fish. It was about three inches in length, and its broadest portion was about one inch and a half. Though the resemblance was certainly striking, so many characteristics were wanting, that I mention it merely in this hurried way. I was rather myself inclined to consider it as the impression of one of those polymorphous bodies before described, and which assume a great variety of shapes and forms.

The above limestones do not appear to contain any metallic veins, or, indeed, many mineral veins of any kind. I have met with veins of calcareous spar in some of them, more especially in the brownish black variety before alluded to, but even this is rare. The general structure of the rock is that of a *uniform fine grained argillaceous limestone*, the surface of which, in many instances, exhibits a *dendritical appearance*, and the quarries of this rock have, in the distance, a *zoned aspect*.

The absence of metalliferous and mineral veins, &c. and of the caverns and fissures which generally characterize the mountain limestone, would appear to distinguish the rock in question from the rocks of that formation, and all things considered, I feel inclined to believe that it is a lias—or, at least a formation nearly allied to the lias. Its *position* leads me to draw this conclusion, and there is nothing either in its *structure*, *mode* of *occurrence*, or *organic remains*, to militate against such a supposition. The Pecten is a shell of the lias, though certainly not a characteristic one.

The formation I have just described *never rises into hills*, but is sometimes seen occupying gentle elevations: the surface of the country where it occurs having a waved aspect. At *Cheetore*, the strata of this rock are much disturbed, and in other situations I have seen similar appearances.

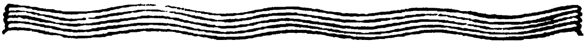
We shall now proceed to describe very briefly another rock which occurs in the belt under consideration; viz. the *quartzose breccia*, before alluded to, and to which Captain DANGERFIELD has applied the name of hornstone. This belt exhibits numerous low rounded hills, hill groups and ranges,—some of the last of considerable extent, more especially the one which forms the boundary of *Meywar* and *Harowtee*. These hills do not rise higher than three hundred feet above the level of the plain, and the majority of them average below this height. Their upper portion is formed of this quartzose breccia, which rests immediately on the sandstones, sandstone slates, &c., which rocks form the base, and very generally the central regions of these hills and hill ranges. This breccia I have never seen *in low situations*, or resting on the limestones. The shape of the hills is sometimes conical. This is particularly the case with detached hills and groups, but the ranges generally exhibit an even and uniform appearance, and the summit is occupied by a table land, or a gently waved plain. Some of the detached hills also present this shape, an excellent example of which we have at *Chitor*, the ancient capital of this country, which is situated on an isolated hill near the boundary range before alluded to.

The slightly waved plain, occupying the summit of the hill on which this ancient city stands, or rather stood, for it is now in a complete state of ruin, is said to be about fourteen miles in circumference. Its length is six miles from N. to S.; its breadth varies from quarter to half a mile

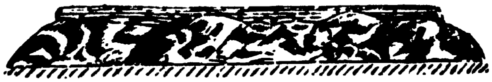
This breccia passes into a variety of quartz rock, sometimes nearly white, more generally ferruginous, and in this case it is of a reddish color; it also occurs of a bluish green color. The purer varieties are distinctly stratified, and some even approach to slaty. The strata are sometimes almost horizontal, in other situations they are waved or saddle-shaped.

The rock in question sometimes assumes a very beautiful aspect. On a hill to the north of *Nímach*, I have seen it with a base of the nature of agate-jasper, containing small rounded portions of quartz, and exhibiting minute drusy cavities, lined with quartz crystals: the whole being capable of receiving a high polish. At *Bárí* it occurs both in the form of a nearly pure quartz rock, horizontally stratified, and of an unstratified breccia, composed of angular portions of pure white quartz, and a red somewhat agatose variety of the same. This rock also occurs exhibiting something of the appearance of the millstone grits.

A very characteristic feature of the hills and hill ranges of this formation, the conical hills of course excepted, is the bluff, in many instances perfectly perpendicular crag, which their summits presents. The bases of these hills, &c. are formed, as before stated, of the sandstones and sandstone slates; and as high as these rocks occur the slope, though abrupt, is uniform. Immediately resting on these is the breccia which presents the perpendicular crag, just alluded to, and which rises from the slope as in the sketch beneath,—the summit being occupied by a table land of considerable breadth, which gives rise to the even and uniform aspect which the summit of these hills present.



This is particularly the case throughout the whole extent of the boundary range betwixt *Méwar* and *Haráotí*, and the hill of *Chítor* affords a noble example of this kind of structure. It is surrounded on all sides by high perpendicular crags, forming a natural fortification, which, till it was taken by Akber, gained it the name of impregnable,—a name which the natives of this country still fondly apply to it. The rock forming the summit of this hill and of the boundary range, is distinctly stratified, the strata being waved or saddle-shaped,—the elevated plain on which *Chítor* stands, exhibiting several smooth round swells, with corresponding hollows between, and the strata appearing to dip in a directly contrary direction on ascending from the east to what they do on ascending from the west. From the summit of this hill, we could observe a similar plain occupying a corresponding position on the boundary range. The diagram below will give some idea of the way in which the strata are arranged at *Chítor*.



The boundary range runs in a direction nearly north and south as far as *Chítor*, where it takes a turn to the east, and in marching from the last place towards *Nímach*, the route running parallel to—and at no great distance from—the base of the hills, the line of demarkation betwixt the two varieties of rock forming them could be distinctly traced, and it appeared to me that the superior strata had accommodated themselves to the form of a previously existing range, filling up all irregularities, and presenting at their summits, the even line before described. The base and lower portions of the hills are covered with vegetation, owing to the softer and less durable nature of the sandstones, &c. forming them; and the crags rising abruptly above this jungle, appear like *huge walls raised artificially*, presenting to the view the bare rock, apparently arranged in horizontal strata, but which, in fact, presents the waved aspect just described. The rocks so situated, as far as I have had opportunities of examining them, are ferruginous quartz, or a siliceo-ferruginous grit, containing occasional beds of breccia. Many varieties of the series of rocks which I have named quartzose breccia, may probably be found in this range.

The rocks of the formation thus briefly described are characterized by the large quantities of iron ore contained in them. This ore occurs in small beds, veins, and in the form of embedded nodular concretions. These latter sometimes exhibit a jaspery aspect—Botroidal red hœmatite, common hœmatite, red iron ochre, and sometimes magnetic iron ore—are met with, and the whole surface of the crag frequently assumes an iron-shot appearance. Iron also occurs in minute grains, disseminated through the mass. This rock, either in its purer or brecciated form, never occurs loose or friable. The cementing medium of the brecciated variety is generally siliceo-ferruginous, and some of the specimens greatly resemble the coarse old red sandstones. I have met with no organic remains in this formation.

I was at one time persuaded that the above rocks were of analogous formation with the *iron sand* of the English Geologists—though in their structure, and in many of their characters, they do not resemble the rocks of this formation, still these characters might have been modified by many and various causes. Their position gives some color to such a supposition, and a breccia, somewhat similar to the one described, is mentioned as associated with the iron sand. On this point, however, I prefer saying nothing more. I am anxious to give as impartial an account of the rocks as they occur, as I possibly can; and it is difficult, when once we have adopted an opinion, to void trying to trace analogies which exist more in our own imaginations than in reality—not that I believe that any individual would willingly deceive in matters of this kind, but the fact is we are deceived ourselves. It is thus that science degenerates into a system of vague hypothesis.

The plains of this portion of the country are strewed with numerous rolled masses of the above rock, and from the isolated position which it occupies, viz. only on the summits of the hills, we may conclude that it has been *much affected by those great denuding causes* which have operated with such amazing force over the whole surface of the globe. How far this formation extends into *Haráoti* I know not—Captain DANGERFIELD in his map, lays down this district as a formation of "*hornstone* and porphyry."—But whether this hornstone be the same rock as the quartzose breccia or not, I have had no opportunity of ascertaining As I before stated, he has applied the name to two rocks of very distinct series. Large blocks of this quartzose breccia are constantly observed at the base of the hills arranged in large globular heaps. These are detached from the crags generally during the rains. The reason of this is obvious. The water having penetrated into the rents and fissures of the rock, is exposed to the heat of a nearly vertical sun, which usually bursts out after the first fall of rain—the expansion thereby occasioned is great, and the blocks in question are detached, while the same cause accelerates the decomposition of the softer and more friable strata—thus affording a thick soil which is rich and fertile, and in many situations covered with jungle.

Regarding the rocks of this narrow belt I have only further to add, that the *strata*, in the neighbourhood of the primitive formations, *are more inclined than in other situations.* This remark holds good in the case of all the rocks of this belt. The wells are seldom deep, water being generally obtained near the surface. This circumstance is owing to the numerous artificial lakes and tanks which have been formed in this district—and it is seldom necessary to penetrate the strata beyond the level of these lakes, and never beyond the level of the nullahs and streams. I may also mention that, in addition to the fact of springs of water issuing from the strata of the low boundary range, &c. as stated by Captain DANGERFIELD, that there is a spring at *Gangra,* twelve miles N. W. of *Chitor*, which issues from the sandstone slates near the base of the group of hills which are there observed. This spring is *sensibly hot.* When I visited it—it was during the cold season, and we had ice daily in our *shorais.* The thermometer in the morning standing below 40°, and during the hottest period of the day, never rising beyond 47° ; but when plunged into this water it rose to 80° It issues from the rock at the surface, and the fountain is looked upon as sacred by the natives. It has no sensible taste, and appears to hold little foreign matter dissolved.*

---

* A bottleful of this water, afterwards subjected to the following tests, gave the results as below. Nitrate of silver throws down a dark precipitate. A paper, dipped in a solution of lead, and plunged in this water, acquires a dark color ; and a solution of acetate of lead, also throws down a dark precipitate. Tincture of galls has no apparent effect, neither has the addition of a large quantity of alcohol. A quantity of the water was boiled, the contact of atmospheric air being

My observations on this belt are confined to its most northern portion, and they may serve as a supplement to Captain DANGERFIELD's account, to which I beg leave to refer for further particulars.

But it is now time that we should return to the consideration of the primitive strata, and I shall premise my remarks on this head by a general description of the external features of the country. The southern portion, then, of the tract under consideration, is mountainous, and consists of numerous groups and collateral ranges of hills, studded closely together, and separated from each other by narrow ravines and deep valleys. These hills do not rise to any great height, seldom to more than five hundred feet above the level of the plains;—they run generally in a northerly and southerly direction, and instances occur where individual hills attain the height of twelve hundred feet. In many situations, too, the country presents a mammillary aspect—an aspect frequently observed to characterise the lower granite tracts in other parts of the world. In this southern portion are included the northern parts of *Guzerat*—the district of *Bayar*—portions of *Rath*,

---

excluded, and to two separate portions of this, the sulphuric and nitric acids, were severally added, no precipitate or cloudiness was observed even on the addition of a large proportion of alcohol to the portion containing sulphuric acid. From this it would appear that *no hydrosulphuret of lime* is present, which is usually the case in hepatic waters. A sediment, in minute quantity, of a light color, and which effervesced with acids, remained after the boiling. This was carbonate of lime. The water boiled and freed from its gases, gave a white precipitate, on the addition of sulphate of silver. From the above it follows, that sulphurated hydrogen, carbonate of lime, and muriatic salts, were present. This water emits the peculiar odour of sulphurated hydrogen, though faintly so when it is perfectly fresh, and the ingredients present appear to exist in minute proportions; the exact proportion I had not the means of ascertaining, as the bottle containing the water was, accidentally, broken after the above experiments were concluded. The muriatic salt indicated by the test, is probably *muriate of soda*. At least a very small quantity of the water which remained in the broken bottle gave, on evaporation, a minute portion of a white substance, having the taste of common sea salt. The quantity was too small to be examined.

Shri, and the south of *Méwar*, and it is inhabited by the numerous and predatory tribes of *Bhils*, Mínahs, *Grasias*, and *Kúlis*. It presents a wild and bleak appearance, and exhibits, on a small scale, all the bold and striking features of an Alpine country. It is traversed by numerous deep and rugged ravines and ghauts, on the brinks of which are frequently seen the villages and huts of the rude people by which it is inhabited. As we proceed north, the country becomes more open—the valleys more extensive, and a narrow belt, exhibiting a mammillary aspect, is very generally interposed between the large and level plains of the north of *Méwar*, of the *Ajmer* district, &c. and the more mountainous tract just described. The same mammillary belt also runs parallel to the great central range of hills so often alluded to, as far as *Kankaraolí*, thirty-six miles north of *Udayapur*, while to the east of this belt we have the usual level plains of the north of *Mewar*. The hilly tract just described may be considered as a continuation of the great central range which may be supposed to divide itself, a little to the north of *Udayapur*, into a number of collateral and concentric ranges, so that it is difficult to say which ought to be considered the parent range—and which not.

Suppose a line drawn west from the cantonment of *Nimach* to the northern extremity of the valley of *Udayapur*, it will give us a sufficiently correct boundary for general purposes, betwixt the northern and southern portions of this district *to the east of the great central range*. The northern portion is characterised by plains of large extent, which are perfectly level, and from the surface of which are seen, here and there rising *abruptly*, hills and small hill ranges and groups. In the neighbourhood of the mountainous district to the south, these hills and ranges are numerous, and they gradually decrease in number as we proceed north, till, on reaching the *Ajmer* district we frequently find ourselves on a perfectly level plain, bounded by the horizon on all sides, and at the surface of which the vertical strata are very generally observed. Still, however, detached groups and hills here and there present themselves. North of *Nasirabad*, these plains are bounded by the great central range, which here takes a turn to the N. E.—East of *Nasirabad*, and proceeding from that cantonment through *Jaypur* towards *Biana*, we have still the usual level plains with their detached hills and groups. These latter, in many instances, appear to form detached portions of two hill ranges, which we meet with about half-way betwixt *Nasirabad* and *Biana*, and which run parallel to, and at no great distance from each other. Frequent secondary ranges pass off from them, generally in pairs, running parallel to each other, and nearly at right angles to the parent ranges. These parallel ranges are separated from each other by perfectly level plains, with the usual detached hills, which are, in this district, generally topped by a fort or a strong-hold, and which rise *abruptly* from the surface, often exhibiting an almost perpendicular crag. South of the most southern of the two ranges above alluded to, we have also plains of large extent, the route in this direction running through the south of *Ajmer* and *Jaypur* and crossing the fertile jageer of AMIR KHAN near *Tonk*. This portion is also characterised by hill groupes and detached ranges, some of considerable extent. The height of these detached groupes, hill ranges, &c. is very inconsiderable; but the plains themselves are situated high above the level of the sea, as may be seen from the measurements made by Captain DANGERFIELD; and there appears to be a gradual slope as we proceed east towards *Bharatpur*. The hills composing the central range, rise higher, and their altitude appears to become more considerable as we proceed north,—none, however, I believe, rise higher than twelve hundred feet above the level of the plains; very few, indeed, so high, and their general average may be estimated at between six and eight hundred feet.

The northern portion of this great tract is very fertile, and is abundantly supplied by water from numerous large lakes, tanks, rivers, and wells. The deep valleys of the southern portion are also fertile, but many of them are indifferently supplied with water. The splendid *Dhábar* lake, however, and several others of smaller size and less note, are situated in this portion of the country, and the great fertility of the valley of *Udayapur*, situated on the northern extremity of this southern portion, I alluded to in my last. The country surrounding *Nasírabad* forms a striking exception to the above rule.—Here the rock almost universally appears at the surface, and where any soil exists it seldom exceeds a few inches in depth.

In spite of all these natural advantages, large tracts of land are left in a perfect state of jungle, and the contrast afforded us on entering the highly cultivated provinces of the British Government, is truly striking. The above circumstance may, in a great measure, be attributed to want of confidence on the part of the Ryots, owing to the insecurity of property, which is but too often the result of Native rule. Besides, this part of India has not yet recovered from the effects of war and famine, which, not many years ago, rendered it almost uninhabited; and I believe that even now, the produce exceeds the demand.

Of the country to the west of the great central range I know little, as I have had no opportunities of examining it personally. We have every reason to believe, however, that the central range forms the highest portion of the district under consideration, with the exception, perhaps, of the immediate neighbourhood of *Abu*,—and that the country to the west of it slopes gradually towards the *Indus*, &c. How far west the primitive strata occur I know not, but that these are succeeded by secondary rocks I have before stated my belief, and I have in my possession specimens from *Serooee*, which belong to the primitive class. I believe that the southern portion of this western tract is characterised by its broken and mountainous aspect, and that some of its hills rise to a very considerable altitude. In this part of the country is situated the mountain of *Abu*, so famous in Hindoo Mythology, which, according to Colonel Todd, rises 5,000 feet above the sea ; and from the district of *Siroki* passes off to the west a range of hills, I believe also of primitive formation. *Siroki* itself, especially towards the north, is described as exceedingly fertile, and capable of being highly cultivated. It is succeeded in a northerly direction by the country of *Marwar*, which is described as lying comparatively low. This last is bounded by the sterile districts of *Bikanér* and *Jesselmér*, which are situated on the confines of the sandy desert—the sands of which make yearly encroachments on the country to the west of the central range—the said range presenting an impassible barrier to their further progress east.

In concluding this branch of my subject, I may remark that those who are in the habit of travelling much in India, are constantly struck with the very different aspect which the same country presents at different seasons of the year, and hence very opposite, and even contradictory, accounts of particular districts may be given by travellers, and all of these may be correct. The increase of vegetation during the rains is a principal cause of this alteration, and it is astonishing sometimes to observe the effects of *light and shadow* in modifying the external features of the country. During the season of the hot winds, when the sky is clear and cloudless, and the sun is reflected with fearful intensity from the bare and barren rocks, nothing but ideas of desolation are excited in the mind, but after the first fall of rain the scene changes as if by enchantment—the wilder and bleaker features of the country are softened down, the desert seems at once to teem with life and vegetation—while the clouds and mists gathering on the mountains here, exhibit them of a dark and sombre hue, and there, spots of green may be observed glittering in all the brightness of reflected sunshine. These causes not only modify the external appearance of the country, but even the *shape of the mountains seems to undergo a change.*

With regard to the Rocks of this District, they are all probably based on granite.—Of this, however, I can offer no proof, except such as are derived from analogy, and many of the granites appear so intimately connected with the other rocks, that it is impossible *prima facie*, to say which ought to be considered the eldest and which not—a gradual passage of the granites into rocks, resembling the greenstones of the trap formation may, in many situations, be observed in this district. Dr. Mucculloch has described similar appearances in Scotland, and has drawn from the circumstance conclusions, the correctness of which I cannot take upon myself either to contradict or support.—I may be permitted, however, to remark, that conclusions drawn from the external characters of rocks; appear to me liable to considerable objections. These may be modified by many circumstances. Neither can I believe that the circumstance of one rock occurring stratified and another unstratified, justifies us in concluding that these two rocks have owed their formation to different causes. In this district we often observe a rock in one situation stratified, and at a little distance from it another of an exactly similar nature, in other respects, unstratified. An instance of this kind I have particularly remarked at *Phulana*, about twelve miles north of *Mérta*, where there occurs a series of alternations of a close grained grey granite, with hornblende rock approaching to primitive greenstone.—Some of the alternating beds appear distinctly stratified, while others resemble an unstratified mass, of a prismatic form, interposed among the other strata. It is impossible to distinguish which is which, betwixt two hand specimens from the different beds, and the above difference is observed over a square surface of several yards. It would be difficult indeed to believe the two different causes had operated in forming these different beds of rock.

That granite does occur oftener in an unstratified than a stratified form I am free to confess. This is particularly the case in the well-marked varieties. It also exists in long-regular-prismatic beds—interposed among other stratified rocks, and alternating with them. These beds are certainly not subdivided into strata, but may not this have been owing to a particular arrangement of the constituent parts, and does not the circumstance of their alternating with other strata, *and the regular prismatic form of the beds, indicate a stratiform structure,* or at least something *very analogous to it.* I stated in a former paper, that I considered the granite which forms the small hills protruding through the deluvium of *Guzerat* at *Pandua,* to the north of *Balasinore,* as belonging to a very old variety, and the out-croppings of a similar formation may, very probably, be discovered in many of the granites of this district. The talcose and chloritic granites, which form the protogine of Jurine, the last mentioned Geologist considers very antique varieties. These occasionally make their appearance here; but, without speculating farther on this very difficult subject, I shall proceed to enumerate very briefly the different rocks which occur in the southern portion of the district under consideration.

I have, on a former occasion, given a section of the strata on the route from *Baroda* to *Udayapur,* and this, in addition to Captain DANGERFIELD's account. and the section of Captain STEWART, in the Bombay Literary Transactions, renders it unnecessary for me to say much on this branch of my subject.

The rocks, then, which principally occur are chloritic and argillaceous schists,—greenstone,—greenstone schists,—quartz rock,—and more rarely, though still in considerable abundance, micaceous schist, granitic rocks,—gneiss,—with occasional beds of serpentine and marble. These rocks pass into each other by insensible degrees, so that it is often difficult to say to which class particular specimens ought to belong. On a general view of the subject I may state, that the argillaceous rocks are more abundant on the southern than in the northern portion of the tract under consideration, while in the latter the granitic rocks, with their accompanying gneisses, micaceous schists, and hornblende rocks, greatly preponderate,—quartz rock being very abundant throughout the whole of Central India. In the neighbourhood of the *Dhábar* lake, granitic rocks. with gneiss, hornblende rocks, &c. are discovered, and a similar formation, but of no great breadth, may be traced from this, running on a northerly and southerly, or south-easterly direction, through a considerable extent of country, the line of continuity being interrupted by the occasional occurrence of rocks of a different nature. This formation may very probably be a continuation of the granitic rocks which occur at *Warí*, in *Guzerat*, as described by Captain STEWART.

The granites have a structure generally intermediate betwixt large and small grained. Their characteristic color is red, but they sometimes occur small grained and of a grey color—the color in the red varieties depending on the felspar which usually exhibits a foliated fracture, and which is, generally speaking, the most abundant ingredient. It is sometimes associated with quartz alone, and this variety is generally large grained, the quartz being white and semi-transparent. Passing into the last the common granite is found, and the mica in this varies from nearly *black*, through olive green, to silver white. I have never met with it in this portion of the country in large plates. To this last, again, hornblende is frequently superadded, and this either replaces the mica, or occurs associated with it in the same mass. Besides the above, talcose and chloritic granites also occur,—and these have occasionally scales of mica disseminated through them. The close grained grey granites are generally composed of mica, quartz and felspar, the last of which is sometimes *granular*.

The gneisses are also very generally of a reddish color, and this last class of rocks seems to pass into the waved sienitic gneiss, described in a former paper, which passes again into a hornblende rock, with which felspar, of a grey color, is frequently associated This last passes into pure hornblende rock, and into hornblende schist. In all rocks where hornblende is abundant, and where felspar is associated with it, the latter is almost universally of a grey or whitish color, and a specimen will be hereafter alluded to which was broken from the junction of a hornblende rock approaching to sienitic granite, and a granitic rock with which minute grains of epidote is associated, in which the felspar acquires a redder tint in proportion as it is removed from the hornblende. This might arise from the coloring matter having had a greater affinity for the hornblende than the felspar, when the *original constituents* of these minerals were in a *state to enable such affinity to be exerted.*

We shall now turn our attention to the QUARTZ ROCK of this district, a rock which appears to me to be of first rate importance. In treating of the Geology on the route from *Baroda* to *Udayapur*, we have had occasion to describe immense beds of this formation, and it is of very abundant occurrence throughout the whole of Central India This rock varies much in its texture in different situations. The purest variety exists in the form of a white semi-transparent rock either stratified or very indistinctly so, and sometimes exhibiting large unstratified beds, very frequently of the regular *prismatic form* alluded to in describing the granites. It either occurs compact or granular, the grains varying from the minutest possible size to the size of a bean, and many of the varieties have a *saccharine aspect*. These latter exactly resemble, in their external appearance, the very pure white, fine grained, primitive dolomites, with which however they cannot, for a moment, be confounded; but it was not without minute examination, and subjecting them to the influence of the common native furnace, that I could persuade myself that some of the varieties were quartz,—they might possibly be confounded with some of the varieties of compact felspar. They are slightly translucent. The quartz rock frequently appears as if composed of a congeries of large angular masses closely cemented together. This appearance, in a great measure, depends on the seams and cracks which traverse the beds in every direction, dividing them into a number of square and rectangular portions. In this last variety, numerous embedded masses of a nearly transparent quartz, forming a coarse rock crystal, occur, indeed almost the entire of some of the beds exists in this last form.

The quartz, on one hand, passes into micaceous schist, which passes again into gneiss, granite, &c.; and on the other, into argillaceous schist. It first becomes distinctly stratified. It acquires a greyish color, and this color gradually deepens; it then becomes more slaty in its texture; mica is sparingly distributed through its substance, and it appears to pass into a harder and more durable variety of argillaceous schist. In many situations, but more especially in the boundary ranges of the valley of *Udayapur*, the connecting link betwixt these two last mentioned series is a rock of a fine granular texture, which occurs distinctly stratified, and has a structure inclining to slaty. Its color is nearly white, and it can with difficulty be scratched by the knife. On exposure, it acquires a beautiful dendritical appearance at the surface, and it passes into a rock of nearly a similar nature, but which is softer and has a greater proportion of alumina associated with the silica, which last, however, appears to be the most abundant ingredient. This rock greatly resembles, in its structure, the fine grained freestones; but it occurs in strata highly inclined alternating with the other rocks. It is seen passing both into the more compact quartz rocks and the argillaceous schists.

A very common variety of quartz rock in this district appears in the form of a compact, fine grained rock,—translucent, or translucent at the edges,—of a bluish color, with sometimes a tint of red, and capable of being split into layers of from half an inch to nearly a foot in thickness, and in the deep ravines in which this portion of the country abounds, many sections of the strata of this rock may be observed. From the compactness and durability of its structure,—from the regularity of its stratification, and the nearly vertical position of these strata—the surface of these crags is often perfectly smooth and perpendicular. This variety occurs abundantly in the boundary ranges of the valley, and forms the entire of the hills which skirt the *Udayaságar* lake, running south, till it is succeeded by the granitic rocks and gneiss of the neighbourhood of the *Dhábar* lake. It is also of very abundant occurrence throughout the whole of the southern portion of the district under consideration. It is the hornstone and columnar hornstone of Captain DANGERFIELD.

Ferruginous quartz is also abundant, and the color of this varies from very dark blackish red to a red of a light shade. The quartz rocks, too, sometimes approach to the nature of the millstone grits, and many of them have a tendency to assume, on exposure, a globular form, the surface of these exhibiting a concentric laminary structure. This is particularly the case with those varieties which have a small quantity of felspar associated with them. Indeed, these last seem. in many instances, to pass into an *imperfect variety* of *granitic rock*. In this the quartz is associated with a considerable proportion of felspar, generally of a reddish colo-—an instance of this kind was alluded to in page 38, and I shall have occasion to describe in my next a series of rocks of this kind, which occur in the boundary ranges of the valley. They are composed of reddish colored felspar and quartz,—the felspar having a tendency to be decomposed and crumble down on exposure. They are sometimes fine grained, but more frequently intermediate betwixt fine and large grained—they have, generally speaking, a porphyritic structure, and pass insensibly into the quartz rocks.

It is not my object in this sketch to trace the different rock formations throughout their whole extent, or to define correctly their limits. I merely wish to give a general account of their structure and mode of occurrence, and as opportunities occur, hereafter to give a more detailed account of individual portions of this extensive tract. To trace correctly the different quartz rock formations, would be a work of great difficulty. They occur very extensively distributed and associated with all kinds of rock. I may remark, however, in a general way, that a belt of quartz, exhibiting, in many situations, craggy and precipitous hills, seems to skirt this great primitive district through a large extent of country, and to separate it from the newer rocks described at the commencement of this paper. Captain STEWART's section exhibits it interposed between the sandstones and the granitic rocks on the route from *Mow* to *Baroda*,—west of the sandstones near *Chitor* I have also seen it, and north of this last mentioned city it still makes its appearance. It is probably a continuation of a similar formation which occurs in the neighbourhood of *Sáhar*, forty miles from *Biana*, in the *Bharatpur* district, which extends to the south and north of the former place, and which is bounded to the east by the rocks described in a former paper as occurring at and near *Biana*. The hill fort of *Sáhar* is situated on an isolated rock of this formation. The hill exhibiting an exactly similar shape to those of *Nakúm*, (see section p. 50.) The rocks of this belt I look upon to be the last formed of the great primitive series of Central India, and they deserve more than any others which I have seen to be considered as belonging to the submedial class.

It would appear that the cause which operated in forming the strata of this district was liable to great, *though not to sudden*, alterations,—that the purest variety of rock formed was quartz,—that to this, under peculiar circumstances, other ingredients were added,—sometimes mica alone, sometimes felspar, hornblende, &c., and sometimes alumina, and that this forming cause had a constant tendency to *revert to that state* to which pure siliceous rocks owed their formation,—the original constituents of felspar, argillaceous rocks, &c being occasionally superadded to those of the siliceous rocks, modifying their external structure, color, &c. according as the former were *more or less abundant*. I here merely state the broad principle without speculating on the nature of this forming cause. The granitic rocks might have been first formed, and the forming cause might have gradually acquired that state to which the pure siliceous rocks owed their formation; this cause might undergo another *gradual* alteration, and thus, from the *superabundance* of one or other of the original ingredients, constituting the solid strata of the earth, various modifications of these might have been produced.

The wonderful powers of chemical affinity—powers to which it is impossible to assign any limits, -and the changes which result from the absence, or presence, or superabundance of particular ingredients, all of which circumstances modify the attractions and repulsions of the original atoms of bodies for each other, are well known to every Chemist, and it is surely not going *too far* to say, that these causes might have operated most powerfully in modifying the external characters of rocks.

The ARGILLACEOUS SCHISTS, with their accompanying GREENSTONE SCHISTS, GREENSTONES, and CHLORITE SCHISTS, next claim our attention. The argillaceous schists vary much in their texture. From the siliceo-argillaceous schists, which pass into the more slaty varieties of quartz rock, to a schist of a loose friable texture, we have a regular gradation. Several varieties of argillaceous schist have been described before (see paper on the Geology of the route from *Baroda* to *Udayapur*,) together with the rocks with which they are associated. They are very generally of a dark grey color, and many of them approach to the nature of roofing slate. These last are generally of a bluish color—other varities are also bluish, but are soft and friable with a slightly greasy feel, the color depending on copper—others are black, making an indistinct mark on paper, while others are light grey, buff, fawn colored, and greenish. The latter pass sometimes into chlorite schist, and at others into greenstone schist. Many of them have mica disseminated through their substance, and these last pass into micaceous schist, while others have a *distinct greasy feel*, and the latter, in one situation, I have seen passing into well marked talcose schist. This last rock does not appear to be of abundant occurrence in this district. The instance alluded to was discovered in the boundary ranges of the valley. The talco-argillaceous schists, or those which have a distinct greasy feel, are, however, common. To the above, the *calc: schiste* of the French may be added, which occasionally presents itself. Thin laminæ, of a whitish colored limestone, in small patches, being disseminated through a basis of argillaceous schist. This forms a calcareo-argillaceous schist.

The argillaceous schists frequently resemble the greywacke schists, as commonly described, and these again pass into greenstone schist and greenstone. The latter, in many situations, perfectly resembles the greenstones of the overlying trap formation, and frequently contains imbedded calcareous spar, as do also the greenstone schists. The greenstones, and less frequently so, the greenstone schists exhibit a porphyritic structure. The low hills of the valley of *Udayapur* consist of a series of alternations of argillaceous schist and greenstone, greenstone schist, &c.—and the greenstones occur both stratified and in regular prismatic beds, alternating with other strata There is another rock which frequently occupies the place of the greenstones in alternations of this last mentioned rock with argillaceous schist, the relative position to the argillaceous schists being similar. It appears to be *greenstone*, which has *lost its hornblende*, and is principally composed of felspar of a greenish grey color, associated with a proportion of quartz, greater or less in different situations. A similar occurrence is described as taking place in Wales —this rock exhibits a porphyritic structure, and somewhat resembles the clay stony porphyry of JAMESON. It is found abundantly in the valley.

Several of the argillaceous schists, especially those which pass into greenstone and greywacke schist, as well as the greenstone schists themselves, are capable of being cut into long masses of various thickness and breadth,—and also into flat slabs. Some of these masses are fourteen feet in length, and are used in place of beams to support the flat roofs of the numerous rectangular buildings of Hindu origin, which abound in this portion of India. The flat slabs are used as roofing stones, and the series of pillars on which these flat-roofed buildings are supported, are also solid masses of the same rocks. These are often fancifully carved. Indeed, these stones are used in place of beams in all the buildings, whether flat-roofed or domed, in this part of the country, excepting in such as are built of marble.

The above series of rocks form by far the greatest part of the southern portion of the district under consideration, and numerous veins of quartz make their appearance in *all* the rocks here observed. Beds of serpentine are also found, generally in low situations, and this last sometimes appears to pass into chlorite schists. Of it tables, and various ornamental works, are fabricated. It occurs unstratified. Marble is not very abundant, but is here and there observed in beds in micaceous schists, gneiss, &c. It is generally large grained, and I believe is also found, though rarely so, associated with the argillaceous schists. A considerable bed of this rock occurs near *Salumbher*.

The strata are highly inclined, sometimes almost vertical. Their general dip is to the N. E. or E. N. E. this is particularly the case with the granitic rocks, &c. They frequently, however, dip to the N. W. and to the intermediate points between N. E. and N. W. sometimes too, though rarely so, they are found inclining in a south-easterly direction. The strata of the softer varieties of argillaceous schist are sometimes considerably distorted, and the more slaty varieties of this last mentioned series frequently exhibit a waved aspect. No change, excepting that of a gradual passage of the one rock into the other, is observed *at the junctions of the various alternating strata.* In some instances where the transition is abrupt, and in alternations of greenstones and argillaceous schists, this is frequently the case. After minute examination, I could perceive no *alteration* or *change of structure* in either of the rocks at their points of junction—the line of demarkation being well marked.

The number of simple minerals in this district appears to be small. Rock crystal, amethyst, but not of any value,—garnets, which last occur in the micaceous schists, gneisses, &c., iron pyrites, which is found occasionally in the argillaceous schists, calcareous spar, -schorl and *actynolite*, with other minerals usually found associated with the granitic rocks, complete the list. The metals are iron, copper, and lead, with which last silver appears sometimes to be associated. The iron is very abundant in many situations—and there are several founderies for this metal. Copper does not appear to be very plentiful, but may be detected in many of the soft bluish varieties of argillaceous schist. On digesting a mass of this rock in nitric acid, a steel rod plunged in the fluid acquires a coating of copper. There is a lead mine at the village of *Jowar?* twelve miles south of *Udayapur*, which occurs in a series of alternations of quartz rock and argillaceous schist, and it is said that a considerable proportion of silver was found combined with this metal, which was worked at one time to considerable advantage. Were this country properly explored, I have no doubt but that many rich mines might be discovered.

A country where such a diversity is perceived in the nature of the rocks must, necessarily, present a bold and striking appearance, and in accordance with this diversity, we observe a corresponding difference in the shape of the hills,—the harder and more durable rocks appearing, as it were, to penetrate through the substance of the softer, and rising in the form of peaks, denticulated ridges, &c. From the extensive distribution of the quartz rock, and from its hard and durable nature, many very striking appearances are exhibited. It is sufficiently obvious, when a hard rock is associated with one of soft and less durable nature, that in the course of time the former will occupy the highest position, whatever might have been its original situation. This, then, is the case when the quartz rocks are associated with the softer argillaceous schists. The latter gradually crumble away, and leave the former occupying the summits of the hills, and presenting different aspects according to the nature of the quartz and the breadth of its beds. A very common appearance throughout the whole of Central India is derived from this source. I allude to the occurrence of a thin bed of quartz, seldom more than a few feet in thickness, often only a few inches, which runs along the ridges of the hills throughout the whole extent, forming a sharp angle from which the darker colored argillaceous schists slope on either side. Where the quartz beds are thicker, they often rise abruptly to the right and left on rugged, nearly perpendicular cliffs—often presenting the appearance of ruined fortifications and castellated walls rising from the slope of the hills, and exhibiting altogether the most striking scenes which I have ever witnessed. Numerous perpendicular cliffs also present themselves—the perpendicular face of these cliffs, being on the opposite direction to that on which the strata dip. This is particularly observed in hills formed of the distinctly stratified quartz rock, described in pages 80 and 81, and even more strikingly so, when the above rock alternates with argillaceous schist, and on the direction in which the strata dip the hills are often almost destitute of soil, the sun being reflected from the bare surface with fearful intensity, while on the other side the slope, especially in such cases, when the outcroppings of argillaceous schist are observed, is covered with jungle, above which the cliffs just described, are seen rising abruptly. The ridge-shaped hills are, however, the most common, and these are generally formed of distinctly stratified quartz, the strata being arranged in a nearly vertical position. From the sharpness of the angle and the regularity of the outline which the summits of many of these hills present,—these summits appear in the distance to be flat, and the deception is increased by their frequently assuming the form of a truncated cone. In the latter instance the sharp ridge still exists It is continued for some distance in a direction parallel to the horizon, and then suddenly slopes on either side at a very acute angle. We have also denticulated ridges, the hills exhibiting this appearance being generally composed of siliceo-argillaceous schists, and the more durable varieties of argillaceous schist while peaks, often of fantastic form, are seen rising above the surrounding hills. The softer argillaceous schists occur generally forming rounc backed hills and gentle swells. While the granites, hornblende rocks which approach to primitive greenstones, &c. are frequently arranged i large globular heaps piled on each other, as if artificially. The pur white quartz rock, too, frequently assumes the form of low rounde swells, entirely destitute of soil, and resembles, in the distance, extende plains covered with snow.

The form of the hills in this district is constantly liable to change—during the rains immense blocks of the harder rocks are detached, an the process of decomposition in the softer and less durable varities is ca ried on with amazing rapidity. Hence its rugged and broken aspect, an this ruggedness is yearly increased by the channels which the hill tor rents are constantly forming for themselves.

That this district has been subjected, at various periods of time, t those violent convulsions of nature which have operated with greater o less force in every quarter of the globe, there can be no doubt. The dee valleys and rugged ravines—the sliding off or sinking of the strata form ing the whole sides of mountains, a narrow ravine only separating the de tached portions from the parent hills,—all which appearances are frequen ly observed in this portion of the country, are sufficient to prove this; bu let not a love for the marvellous lead us beyond the limits which reaso has prescribed. The difference observed in the nature and durability c the rocks, and their capability or the reverse of resisting the decomposin effects of the atmosphere, of the mechanical effects of water, &c. will ac count for very many of the appearances described, and in a climate lik this these causes operate with amazing force.

In this district too, we can trace appearances which have probably resulted from the LAST GREAT FLOOD to which our planet was subjected, in the huge blocks and rolled masses which frequently present themselves detached from the beds in which they originally occurred, and at a great distance from them. The sharp angular appearance of these fragments indicate that they were not long exposed to the action of water. Immense tracts present themselves strewed with angular blocks and masses of the white quartz, which has been described as being characterised by its numerous seams and cracks, and which, owing to this circumstance, was peculiarly liable to be detached from its original position; and in many situations I have observed heaps of the masses of this rock piled upon each other as if artificially, and resting on low rounded hills, composed of a similar variety of quartz. It is impossible, on witnessing these, not to conclude that higher hills, formed of this rock, originally existed in such situations, and that all that now is left of these are the heaps just alluded to, which still remain to mark the spot where mountains have existed before—and we cannot fail to perceive the ruins of these mountains in the masses of quartz which strew the country far and near.

It is impossible, from facts of this nature, to arrive at any certain conclusions regarding the direction from which this flood came. Cross currents and a thousand other circumstances must be taken into consideration; but from the general position which these detached fragments occupy, I am inclined to believe that it came from the west or north-west.

GEOLOGY OF THE NORTHERN PORTION.—We shall now proceed to describe, as briefly as possible, the Geology of the northern portion of the district under consideration. The great difference in the external appearance of the country betwixt the northern and southern portions, has already been pointed out, and my observations are confined to that part of it which lies east of the central range.

With regard to the central range itself, in the neighbourhood of *Udayapur*, it is formed of the distinctly stratified quartz rock described in page 62, —which alternates with argillaceous schists, &c. and exhibits sharp and denticulated ridges, peaks. &c. As we proceed north, the granitic rocks make their appearance with their associated gneisses, micaceous schists, and hornblende rocks. These are found at no great distance to the north of *Udayapur*, and on the most northern portions of *Mewar*, in the *Ajmer* district, and where this range borders on *Marwar*, they are the only rocks met with. From the large plates of mica, which are brought from the latter portion of the district, we may judge of the nature of the rocks of this range to the north.

The country lying betwixt this range and the belt of secondary rocks, which form the *Chitor* range, and from thence extend west for a short distance, is generally level, and from its surface rise several detached hills and hill ranges. The nature of the rocks in this portion of the country will be understood from the accompanying section of the strata which occur on the route from *Nimach* to *Mertah*, which last is situated about a mile and a half from the base of the central range. These rocks cross the country in an oblique direction, the strata running nearly from N. W to S. E.

Proceeding north from *Mertah*, we have a continuation of the rocks described in the explanation of the section as occurring at and near *Mertah*. In these, the associated felspar is frequently *granular*, and the last sometimes occurs nearly pure, in which case it forms the *white stone* of WERNER. This, however is rare. Beds of semi-transparent quartz also occur, and in some instances this rock assumes an almost schistose aspect. When this last is broken in a direction parallel to the schistose structure, minute scales of mica may be frequently observed, which divide the mass into a number of thin parallel bars. The mica cannot be observed in the unbroken mass, or in the cross fracture, and the bars are sometimes so thin that the rock assumes a *fibrous* appearance.

When felspar occurs associated with hornblende, the former is generally white or grey, and in some specimens of sienitic granite, I have observed that the felspar, when exposed at the surface, has acquired a reddish tint, and it is only on breaking the mass that we discover its real color. In one hand-specimen, broken from the junction of a hornblende rock approaching to sienitic granite. and a close-grained granitic rock, through which are disseminated minute yellowish green specks of a mineral, which appears to me to be *Epidote*,—the felspar of the hornblende rock is grey, while that of the other is reddish; the felspar acquiring a redder tint in proportion as it is removed from the hornblende. Through many of the granitic rocks which occur here, the minute green specks just alluded to, are disseminated. When these rocks are exposed to a powerful heat, the green color of these specks is converted into a black, and a similar mineral occurs intimately associated with a rock which appeared to me, on first seeing it, to be a variety of a schistose quartz. It has a specific gravity, however, varying from 2-9 to 3-4, or even 3-5, according as this green mineral is in larger or smaller proportion. This last appears to be translucent at the edges, to have a fracture slightly foliated, and something of a fibrous structure. Its hardness is intermediate, between that of felspar and quartz—it is rather brittle, and before the blow pipe, or when exposed to a powerful heat, it is converted into *black* or *dark brown scoriæ*. Its color is light yellowish green, and sometimes greyish green. It appears to be a variety of Epidote, and the rock just described occurs in considerable abundance.*

In the series of rocks under consideration, chlorite appears frequently to occupy the place of the hornblendes, and the rocks containing this mineral have, sometimes, a structure approaching to that of gneiss,—the chlorite being arranged in nearly parallel, interrupted layers, alternating with layers of the other ingredients. This last rock is distinctly stratified, and passes into chlorite schist. Chlorite also occurs in minute quantity in many of the rocks approaching to the nature of white stone.

In the neighbourhood of the central range, in this part of the country, we have numerous detached ranges, and the surface of the country, on proceeding towards *Náth'dwára*, becomes rugged and uneven, exhibiting a mammillary belt, in which are situated several deep and small valleys. The rocks observed are different modifications of granitic rocks, alternating with hornblende rocks. *Náth'dwára* (famous for its temple, which is one of the most sacred in India, with those of the *Vaishnava* persuasion,) stands about twenty-four miles north, and a little to the east of *Udayapur*. It is situated on the inner slope of a group of hills of a rugged aspect, and which group is connected with the mammillary belt above alluded to. The rocks which occur there are argillaceous schists, containing a large proportion of mica, and these pass into micaceous schist, which alternates with quartz rock passing into gneiss. The *Banás* river, skirts this group. For about four miles east of *Náth'awara*, we have still numerous detached hills and groups, and the country is broken and rugged,—we then enter the level plains of *Mewar*.

---

* In addition to this mineral, I suspect that Schiller spar occasionally occurs. Associated with the quartz is a rock which has a specific gravity of about 2·8. It is so intimately blended with the quartz, however, that I could not determine with any degree of precision respecting its nature.

In the district north of *Náth'dwára*, including the most northern portions of *Mewar*, and the *Ajmer* and *Jaypur* districts, we find granitic rocks, gneisses, micaceous schists, and hornblende rocks, with occasional beds of marble and serpentine—while the argillaceous rocks are rare. But before describing these, it may be as well to give, in this place, a short description of the Geology of the country on the route from *Náth'dwára* to *Kankaraulí*, distance of about nine miles north, and slightly east. This portion of the country acquires importance from the marble quarries which abound in it.

Proceeding then north from the *Banás* river. the route running parallel to, and at no great distance from the central range, the country exhibits a mammillary aspect, and to our right stretch out the level plains of *Mewar*. The first rocks which present themselves, are micaceous schists approaching to argillaceous schists, which appear to pass, on one hand into argillaceous schists, with which a large proportion of mica is asso ciated, and on the other, into gneiss, generally of a schistose structure. Small thin laminæ of a white limestone, occasionally occur in patches in the schistose rocks, forming a variety of the *calschiste* of the French. The preponderating rock, however, is micaceous schist, in which occur beds of quartz and hornblende rocks.

On arriving at *Kankaraulí*, several low ranges of hills are observed. The Lake, for which its sacred city (for it, as well as *Náth'dwára*, is the seat of a Gosain of the Vaishnava persuasion) is famous, may be about fourteen miles in circumference. It is skirted on two sides by these low ranges, and on the other sides the water is confined by two *bunds* of large extent, and there is another *bund* which blocks up a broad ravine which separates two of the ranges just alluded to.

It is in these ranges that the marble formation of *Kankarauli* occurs. On the side to which the strata dip, the acclivity is gentle ; but in the opposite direction, they present bluff crags which overhang the lake. The marble occurs in distinctly stratified beds. In a hill examined, the first rock which presented itself was micaceous schist, composed of quartz and mica, the last in large proportion, and in silvery plates of considerable size. Dipping under this, occurred a thick bed of marble, the outcroppings of the strata making their appearance throughout the whole extent of a low ridge skirting the lake. Under this again, a micaceous schist, of a more stony aspect than the last, occurred. This contains a considerable proportion of associated felspar, and passes into a gneiss of a slaty structure, which is succeeded by a sienitic granite, or rather a hornblende rock, with which is associated a very large proportion of hornblende. All these rocks are distinctly stratified and dip at an angle of about 45°—the dip being southerly, a little inclined to the east.

The marble which I had an opportunity of examining, was coarse-grained and crystalline. One variety was nearly pure white, while another was greyish white, the last being rather of a closer texture,—both were slightly translucent at the edges, and in their structure they frequently approached to *slaty*. This marble is a primitive *dolomite*. It is dissolved slowly, but entirely in nitric and muriatic acids, with *slight effervescence*, and contains a considerable proportion of carbonate of magnesia, associated with the carbonate of lime. The marble quarries from which all this portion of India is supplied, occur a few miles from this town, and near another lake of smaller size, called the *Rajnagar*. This marble is more compact and fine-grained than the variety just described, and is associated with a similar variety of rocks.

The Bunds which are constructed of marble, have a very imposing a earance, and numerous *flat-roofed* buildings, supported on pillars, exhibiting very richly carved specimens of Hindu architecture, adorn the principal of these. These buildings are completely covered with figures of the Hindu deities, carved in alto relievo. The strata of this limited portion of the country generally dip in a southerly direction, while those in other situations, to the N. S., and in the same parallels of latitude, generally dip to the N. E.

The ranges run in a direction parallel to the direction of the strata, and the micaceous schists and gneisses of this series generally contain embedded garnets.

With regard to the other portions of this district, north and east of *Kankarauli*, I may remark, in a general way, that in it are probably discovered, in any abundance at least,—the oldest rocks which occur in Central India, and these may very probably dip under the argillaceous rocks of the south. The whole of which last series would appear to repose against micaceous schist, passing insensibly into gneiss, the last passing again into granite. Immediately to the north of *Kankarauli*, we enter a perfectly level plain, which is continued to the base of the central range, which range rises abruptly from its surface—and, supposing a line drawn in a north-easterly direction from *Kankarauli* to the fort of *Baníra*, situated forty-two miles north of *Chitor*, we have to the N. W. of this line a perfectly level plain, at the surface of which the primitive strata constantly appear—and this plain is, in many situations, bounded by the horizon, not one single detached hill or range making its appearance till we approach the hill groups at and near *Banái*, which lies nineteen miles S. E. from *Nasírabad*.

To the S. E. of this line we have also level plains, but from the surface of these rise numerous detached hills and hill ranges—and a range of considerable extent stretches in a south-westerly direction, from the fort of *Banira*. The first rocks which present themselves are micaceous schists, in which the mica is abundant, and in plates of considerable size; in these are embedded garnets. Beds of quartz, and a micaceous schist, approaching to argillaceous schist, are frequently met with—and the latter of these rocks is more abundant towards the south. For a very considerable distance to the north of *Kankarauli*, and from thence east to *Bhilwara*, situated thirty-four miles north of *Chitor*, the micaceous schists still preponderate, and they alternate with hornblende rocks and quartz. In the neighbourhood of *Bhilwara*, we observe an extensive series of alternations of this kind; and the hornblende rocks, which occur in great abundance, exist in the form of hornblende schist,—hornblende rock, and hornblende rock approaching to sienitic granite.

Proceeding north, the granitic rocks preponderate, and the range of hills, on the termination of which to the north, *Banira* is situated, is entirely composed of granite. The granites of this range are various, and the different varieties alternate with each other,—some of the beds being stratified, and others assuming a regular prismatic form. One variety is a very fine-grained grey granite, of a crumbling nature, easily affected by the atmosphere, and, in its partially decomposed state, exactly resembling a sandstone. Another variety is a granite, in which quartz and felspar occur in large angular concretions, the quartz being white and semi-transparent, and the felspar being nearly opaque, and of a milky white color—with these a very small proportion of mica is associated. This last rock was traversed by veins of felspar, or rather adularia, of a beautiful pearly lustre. Another variety of granite also occurred, in which the *mica*, of a dark olive color, *was distinctly crystallized, as were also occasionally the quartz and felspar*. The last variety is large granular. The hills of this range are low, and they do not rise higher than three hundred feet above the level of the plain. Their shape is round, approaching to conical.

On leaving *Banra,* we enter the level primitive plain, described in pages 79 and 80—and this plain is, in many situations, almost literally covered with garnets, giving to the face of the country a red aspect. The precious and common garnet both occur. The former is small, and seldom in perfect crystals—the latter is large, often the size of a hen's egg, and is regularly crystallized in the usual manner. The rocks are still different modifications of granitic rocks, with which are associated occasional beds of hornblende rock, and hornblende schist—the first passing into sienitic granite. Some of the granites are composed of quartz and felspar alone, the latter being milky white, and the former semi-transparent. These are arranged in large angular concretions, and have at a little distance quite the aspect of calcedony. This rock is stratified, and felspar in thin seams, which run parallel to the strata, occurs in it. This felspar is translucent, of a slightly greenish color, and easily breaks into fragments of a rhomboidal form. It exhibits, in some small degree, the play of colors so remarkable in the Labrador felspar. Besides the above granites, composed of quartz, bright flesh-colored felspar and steatite occur,—the last ingredient being sometimes wanting; common granite is also found—in this the mica, as seen in the mass, is of a brass yellow color, but when placed between the eye and the light, is of a greenish straw color. Schorl is occasionally met with in these granites, and in their structure they vary from fine grained to large grained.

The above rocks are continued till we approach *Banái,* nineteen miles south-east of *Nasirabad,* when we now again perceive numerous detached hills and hill groups—and rocks containing hornblende preponderate. The rocks heretofore met with have, generally speaking, been regularly stratified, and the strata appearing to cross the country obliquely, and running nearly north-west and south-east.

Banái is situated at the base of a group of hills, which, though they appear smooth and conical in the distance, are found, on nearing them, to be entirely destitute of vegetation, the rock of which they are composed having a tendency to assume the form of large globular, or rather *columnar* masses, which are piled on each other,—one of these masses frequently occupying the very summit of the hills, and presenting a very striking appearance. A small fort tops a low, conical, and precipitous hill, or rather crag,—the fort appearing to rise from the rock, and to be a continuation of it.

The rock composing this group of hills does *not* appear to be stratified. In its texture it inclines to small granular. It is composed of grey felspar, quartz, and black shining hornblende, and has a structure similar to that of gneiss, the hornblende being arranged in slightly interrupted nearly parallel layers, alternating with layers of quartz and felspar intimately mixed. Small garnets occur disseminated through this rock, and in many situations it has a perfect gneissy structure. It may be classed with the sienitic gneisses.

Proceeding from this last place towards *Nasírabad*, we have alternations of granitic rocks, with hornblende rocks and gneiss, all these passing into each other—hornblende being a common ingredient in all. Large rounded heaps of these rocks are seen piled upon each other near the route, and they do not occur stratified, but in large and broad prismatic beds, running in the usual direction of the strata of this district. The route from *Banái* to *Nasírabad* is in a direction nearly parallel to, but a little to the west of, the direction in which these beds run, and we frequently meet with the same rock for the distance of one or two miles.

The country surrounding *Nasirabad* is bleak and desolate. The cantonment itself is situated on an elevated plain, exhibiting, in almost every position, the out-croppings of the vertical strata; and the soil, where there is any soil, is seldom deeper than a few inches. The surface rises into several low rounded swells, destitute, or nearly so, of vegetation and in the neighbouring country several detached hills and hill groups are observed. To the west and north-west, the central range of hills is seen to stretch. It presents a bleak and rocky outline. It rises abruptly from the plains, and in some situations exhibits peaks, frequently of considerable altitude,—some of them, in the neighbourhood of *Ajmere*, rising about one thousand two hundred feet above the level of the plain. In this portion of the country there is scarcely a single tree observed.

The rocks which occur are different modifications of granitic rocks, alternating with each other in narrow beds, and these are associated with gneiss, micaceous schist, and hornblende rocks. All these pass into each other by insensible degrees. The hornblende rocks pass into greenstone, and also exist in the form of pure hornblende rock and hornblende schist, with both of which felspar occurs associated, and these last pass into sienitic granite. The gneisses are generally schistoses not waved, and the granites are very various—sometimes large grained, but more generally small grained. In the above, beds of pure white quartz occur,—these last frequently rising into hills completely destitute of vegetation. The quartz, exhibiting a saccharine structure, described in page 62, is found here, and other varieties are semi-transparent. Some also exhibit an almost schistose structure, and are similar to those described in page 73. Indeed, the whole series of rocks which occurs at *Nasirabad*, is very similar to that described as being met with at and near *Mertah*. The rocks of this series are, generally speaking, stratified, and the strata run in a direction N. W. and S. W. probably skirting, through a large extent of country, the western limits of the formation described at *Banái*, and exhibiting in their course different appearances. The granitic rocks found in the neighbourhood of *Shapoora*, fourteen miles east of *Ban ra*, are probably a continuation of this series, while a continuation of the *Banira* rocks may probably be discovered in those to the west of *Nasírabad*.

Proceeding east from *Nasírabad*, in the direction of *Biana*, we pass, in the first instance, through the same bleak and desolate country—the rocks every where appearing at the surface. We have still alternations of granitic rocks and hornblende rocks, with numerous low rounded swells, composed of pure white quartz, large masses of which latter strew the line of march. The granitic rocks lose, at a short distance to the east of *Nasírabad*, their stratiform structure, and frequently appear at the surface in the form of immense lenticular masses, often many yards in diameter, the superior flattened surfaces of which only protrude; and we also observe the piled up heaps of globular masses above alluded to. This formation is obviously a continuation of that observed at *Banái*. Proceeding east as far as *Bambolí*, about thirty miles distant from *Nasírabad*, we have a continuation of a similar variety of rocks, but micaceous and chlorite schists now occasionally make their appearance; the granites, however, preponderate, and in these the felspar is the most abundant ingredient. It is frequently of a crumbling nature. Among other varieties of granite which occur near *Bambolí*, there was one of a very beautiful appearance composed of quartz-hornblende, the last in very small proportion—flesh-colored felspar, and green mica, and in this rock were imbedded portions of a semi-transparent, nearly white, felspar of a rhomboidal form, giving to the mass a porphyritic structure. Numerous detached hills occur in this neighbourhood. They are all very low—some exhibiting the above described appearance of globular heaps piled upon each other—others are smooth and conical, while others are peaked.

Still proceeding in the same direction, about half way betwixt *Nasirabad* and *Biana*, we perceive the two parallel ranges of hills described in page—, and between which ranges our route lies. These ranges seem to terminate to the west in a number of detached hills which rise here and there in the line which the ranges would have followed had they been continued. Some of these detached hills are conical, others are round, while others are occasionally peaked. The rocks are still granites, some of them containing imbedded actinolite, and with others steatite and chlorite occur associated. Gneiss and micaceous schist are also observed, and the last, as we proceed east, becomes very plentiful. Many of the specimens of gneiss have a zoned aspect, parallel layers of red felspar being observed in these, alternating with layers of quartz, &c. and this last rock, in some situations, passes into quartz, the connecting link being a rock composed of parallel bars of quartz, separated from each other by plates of mica. At a small village called *Gherwási*, about eighty-six miles from *Nasírabad*, occurs a low hill, composed of micaceous schist, with subordinate beds of gneiss and granites, into both of which it appeared to pass. I here found specimens of a variety of *fibrous* quartz of a slightly reddish tint—the fibres were arranged in a manner similar to those of fibrous gypsum, and it occurred imbedded in the rocks in oblong portions of small size, the superior and inferior surfaces of which were slightly convex.

Proceeding in the same direction, the above rocks are still observed, and small grained granites, composed principally of quartz and felspar, with which occasional minute scales of mica are associated, preponderate as we proceed east. Beds of micaceous schist and quartz are also met with,—and the rocks just alluded to are succeeded by the quartz rock formation, in the centre of which stands the hill fort of *Sákar*, or *Onska Sákar*—see page 65. Felspar, in small proportion, occasionally occurs associated with this quartz.

The hills of the parallel ranges which bound to the right and left, the plain over which the line of march lies—are low. Their summits very frequently present a sharp ridge, the acclivity on each side being rapid, and this ridge exhibits an even and uniform line. Sometimes, too, the summits are flattened, and their outline altogether is exceedingly monotonous, the even line which these summits exhibit, being frequently continued for miles without interruption. This is more particularly observed in the most eastern portion of the *Jaypur* district, while to the west denticulated ridges occasionally occur, and sometimes, though rarely so, low conical peaks present themselves. The hills which rise from the plain, especially those of the quartz formation, are more abrupt and precipitous.

Proceeding from the hill fort of *Banmra* N. E. towards TONK, we have still level plains with their detached hills and hill ranges, and these hills become more numerous as we proceed east,—several small ranges too, are seen running on a north-easterly and south-westerly direction. The country is generally covered with soil, from which occasionally protrude granitic rocks, &c., and these are probably a continuation of the rocks observed at and near *Nasirabad*, and to the east of this cantonment; and about twenty-six miles N. E. from *Banmra*, we observe several hills composed of granite rocks, gneiss, &c. in large unstratified beds, the large lenticular masses described in page 84, together with the hills formed of the globular masses so often alluded to, being frequently perceived. This last formation is probably a continuation of that perceived at *Banái*, &c.

A village called *Tora*, is situated at about twenty-four miles S. W. of TONK, and stands near the base of a considerable range of hills, which runs in a north-easterly and south-westerly direction. The hills of this range exhibit ridge-shaped and denticulated summits, and the preponderating rock is gneiss, on one hand passing into micaceous schist, and on the other into granite. In some of these the felspar exists in the form of a soft earthy substance, *(kaolin,)* sometimes it is of a reddish color, and at others it is greyish white. The last is frequently granular.

The country surrounding Tonk is characterised by its numerous detached groups, and the hills often rise into peaks of fantastic form, denticulated ridges, &c. Many of them are entirely destitute of vegetation, and a sharp craggy peak, of a very striking appearance, and crowned by a domed building, overhangs the city. The rocks observed are granitic rocks passing into gneiss, quartz being a very abundant ingredient in these.

Proceeding N. E. from Tonk towards *Sowáli*, situated in a pass in the most southern of the two parallel ranges, alluded to in page 85, and distant twenty miles S. W. from *Sáhar*, the detached hills are still numerous, and many of them are crowned by a strong-hold. The windings of the *Banás* river are frequently crossed, and the rocks gradually pass into quartz rock, approaching to gneiss, with which hills of micaceous and chlorite schists are associated.

Five miles to the S. W. of a small village called *Bopái*, which stands about twenty-six miles S. W. of *Sowáli*, is a hill fort, of a very imposing appearance. The small detached range, on the highest point of which it is situated, appeared principally composed of quartz of a white color. The lower and central regions of the hills were covered with stunted jungle; the rock then suddenly took a more perpendicular direction, and rose by a very steep acclivity, till, with the slope on the other side, it formed a sharp denticulated ridge, frequently rising into needle-shaped points, and exhibiting a peculiarly *bristled* aspect. The upper regions of these hills were entirely destitute of vegetation. Many other of the hill ranges presented similar appearances, and we had also the usual ridge-shaped hills, and some were conical.

On approaching *Sowáli*, these detached ranges were still very numerous, and the secondary ranges, described in page 56, were seen passing off in pairs from the range, at the base of which *Sowáli* is situated. I need scarcely add that the word "*secondary*" has no reference, in this place, to the rocks of which the hills are formed, but is merely used as a relative term to express the connexion of these ranges with the greater range. These secondary ranges, then, are not continued far, but terminate a short distance to the south. Their summits present various appearances,—some are flattened or slightly rounded, and are bounded on either side by nearly perpendicular smooth crags which rise abruptly from the slope. Others are ridge-shaped, while others are slightly denticulated.

The rocks which present themselves are small grained granitic rocks, the quartz and felspar being by far the most abundant ingredients, and these are associated with micaceous schists and quartz rocks. Succeeding these, the quartz formation of *Sáhar* occurs.

The above is all the information which I can give relative to the Geology of this district. My communication has already been extended beyond the limits which I at first proposed for myself, and my concluding observations shall be few and general.

In the northern portion of this district, I stated that beds of marble and serpentine are found, excepting, however, the marble formation of *Kankarauli*. I have not had an opportunity of examining these, and shall therefore content myself with remarking, that marble appears to be plentiful in the northern portions, both of *Ajmer* and *Jaypur*.

Regarding the metals of this district I can say but little. During the past cold season, I had proceeded as far as *Nasirabad*, for the purpose of examining the *Ajmer* lead mines; but the sudden calls of duty obliged me to return to *Udayapur*, when I was on the very point of setting out on my intended excursion. I can, therefore, give no additional information to what is already known respecting these mines,—and I must be satisfied with remarking, in a general way, that iron, copper, and lead, with which last silver has occasionally been found associated in small proportion, are the only metals which have as yet been found in this district. Several specimens were shown me as ores of antimony. These were, however, well-marked galena. There are several iron founderies in this district, and this last metal appears to be very abundant in the quartz rock formation. Copper mines, too, have, I believe, been worked near *Mandal*, in *Mewar*.

Several simple minerals have been mentioned as occurring in the granitic rocks, &c.; and in one variety of granite was observed a mineral which appeared to me to be Saussurite.

The depth of the wells in the primitive portions of Central India appears to depend, in a great measure, on their being near, or at a distance from—the large lakes which abound in this district, and the remark first made by SHAH BABER, (see LEYDEN, and ERSKINE'S translation of his life,) who appears to have been a wonderfully intelligent observer of nature, I have found to be perfectly correct. This remark is, that in the apparently dried-up courses of rivers and nullahs in India, water is universally found close upon the surface, and that, even during the hottest periods of the year, it is only necessary to dig a few feet through the sand to reach it. We cannot but agree in the reflection made by this monarch upon stating the circumstance; viz. that it presents an instance of one of the many bountiful arrangements which Providence has made to supply the wants of its creatures. Many of the wells at *Nasírabad* are eighty feet deep, and are bored through the solid rock—the water in these is generally *brackish*—and is impregnated with saline ingredients. The hill fort of *Hamírgher*, situated twenty-one miles north of *Chitor*, is remarkable on account of a well which has been bored, with infinite labour, through the solid rock from the summit to the very base of the low hill on which the fort is situated. This well is nearly two hundred feet deep.

During the rains, springs of water may be seen, in many of the hilly districts, issuing from the rocks at the surface.

In the north of *Ajmer* and *Jaypur*, the water is bad and brackish. In the southern districts it is excellent; and the only foreign ingredient which I have as yet detected in it is carbonate of lime, which sometimes exists in considerable proportion. A quantity of carbonic acid gass, in a free state, must, of course, exist in these waters. to enable them to hold the carbonate of lime in solution.

With regard to the Geology of the primitive portion of the district to the west of the central range, I can say nothing. My specimens from the *Serooee* district are as follows, and these indicate a similar variety of rocks to those which we have described as occurring to the east of this range: 1st, a rock composed of pure black shining hornblende without intermixture; 2d, nearly the same as the above, but with associated felspar in small proportion; 3d, a sienitic granite, approaching to primitive greenstone; 4th, a granitic rock, composed of flesh-colored felspar, with a distinct foliated fracture, quartz in much smaller proportion, and of a white color, and steatite—the last in very small quantity, and in other specimens of the same rock entirely wanting—this granite is very large granular; 5th, a sienitic granite intermediate between small and large granular, and principally composed of grey felspar, with which is occasionally associated quartz and hornblende, the last in minute proportion—a soft reddish iron ochry-looking substance occurs disseminated through this variety; 6th, a very compact primitive limestone, with a texture approaching to that of calcareous spar; 7th, a limestone, or marble of a whitish color, consisting of a congeries of minute grains, which appear to the naked eye rounded, but which seen through a microscope have an imperfect crystalline structure, exhibiting sharp angles, &c.—through this rock is disseminated minute scales of a dark colored mica; 8th, a limestone somewhat similar to the last, of a cream-color, composed of similar grains in a very loose state of aggregation, so that it crumbles into a fine calcareous sand almost on being handled. Through this rock are disseminated scales of an olive-colored mica, and a portion of it being thrown into nitric acid, the calcareous grains were completely dissolved with brisk effervescence, while there remained as a residuum, the scales of olive-colored mica, a few minute grains of quartz, and two other minerals, the nature of which I do not altogether understand.

One occurred in small cylindrical grains, or rather six-sided prisms, the lateral planes of these not being very well marked, but at the same time sufficiently distinct to entitle them to the appellation of crystals. They are about the size of a grain of rice, are slightly translucent, approaching to opaque—of a white color and silky aspect they are soft, and easily crumble between the fingers into a fine silky looking powder. Before the blow pipe they acquire a more opaque degree of whiteness, and they do not appear to be affected by acids. Their specific gravity does not seem to exceed 2° 00, but from the smallness of the size of these crystals, and from their lightness, I could not ascertain this point with precision, not being possessed of scales sufficiently delicate.

The other is of an emerald-green color, translucent or semi-transparent. It occurs in grains or crystals of nearly a similar form to the last, but these are frequently flattened. It also occurs in small irregular grains which assume no distinct form. Like the first, it exhibits a very fine fibrous structure. It has a shining vitreous aspect—it is soft, so as to be scratched by the knife, but it is harder than the other; it is exceedingly brittle. Its fracture appears to be foliated, and its specific gravity does not exceed that of the last. When exposed to the flame of the blow pipe, it acquires a darker color, and becomes opaque and friable.

The above minerals appear to be more allied to apatite, than to any other substance with which I am acquainted. The friend to whom I am indebted for my specimens informed me, that the rock in which these are found occurs very abundantly on the route from *Udayapur* to *Seroí*. A specimen of this rock I have the pleasure to forward.

I have only further to add, that I have found imbedded in *kunker*, in the valley of *Udayapur*, several varieties of primitive rocks, which I have not yet been able to discover in situ. Of these I may mention one. It has a waved appearance, is close grained, almost compact, and consists of white quartz and a dark colored limestone, arranged in waved alternating layers. It effervesces strongly with acids. A specimen of this rock I have also the pleasure to forward.

granular; 5th, a sienitic granite intermediate between small and large granular, and principally composed of grey felspar, with which is occasionally associated quartz and hornblende, the last in minute proportion—a soft reddish iron ochry-looking substance occurs disseminated through this variety; 6th, a very compact primitive limestone, with a texture approaching tc that of calcareous spar; 7th, a limestone, or marble of a whitish color, consisting of a congeries of minute grains, which appear to the naked eye rounded, but which seen through a microscope have an imperfect crystalline structure, exhibiting sharp angles, &c.—through this rock is disseminated minute scales of a dark colored mica; 8th, a limestone somewhat similar to the last, of a cream-color, composed of similar grains in a very loose state of aggregation, so that it crumbles into a fine calcareous sand almost on being handled. Through this rock are disseminated scales of an olive-colored mica, and a portion of it being thrown into nitric acid, the calcareous grains were completely dissolved with brisk effervescence, while there remained as a residuum, the scales of olive-colored mica, a few minute grains of quartz, and two other minerals, the nature of which I do not altogether understand.

One occurred in small cylindrical grains, or rather six-sided prisms, the lateral planes of these not being very well marked, but at the same time sufficiently distinct to entitle them to the appellation of crystals. They are about the size of a grain of rice, are slightly translucent, approaching to opaque—of a white color and silky aspect they are soft, and easily crumble between the fingers into a fine silky looking powder. Before the blow pipe they acquire a more opaque degree of whiteness, and they do not appear to be affected by acids. Their specific gravity does not seem to exceed 2° 00, but from the smallness of the size of these crystals, and from their lightness, I could not ascertain this point with precision, not being possessed of scales sufficiently delicate.

IV.

ON THE

FORMULÆ FOR CALCULATING AZIMUTH IN TRIGONOMETRICAL OPERATIONS.

By Captain G. EVEREST, F. R. S. M. A. S., &c.
Surveyor General and Superintendent of the Great Trigonometrical Survey of India.

In offering to the notice of the Society the accompanying paper, I beg to explain that my object is to put on record certain formulæ, connected with the method generally employed in the Trigonometrical Surveys of England and of India, for determining Azimuths.

Those of my readers, who are familiar with this subject, will remember that the method in question consists in observing the difference of Azimuth between a fixed lamp of reference and some circumpolar star, generally *α* ursæ minoris, at the time of its greatest distance on the east or west side of the meridian.

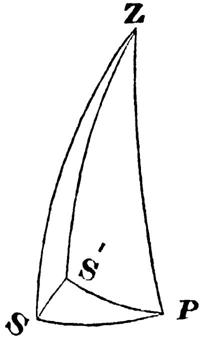
But to accomplish this, the actual time of the phenomenon, and frequently the altitude, require to be known, and as it is advisable to have these elements prepared for the occasion at leisure, the latitude of the place is sometimes drawn from data to which the final corrections have not been applied, and the polar distance is perhaps taken from a catalogue which succeeding observations have shown to be imperfect.

The second part of this paper is intended therefore to furnish formulæ, whereby the observer may introduce the required corrections without undergoing the toil and loss of time which would attend a formal recomputation of the whole set of observations, and it will be remarked that the second hypothesis will also enable him to compute, by means of differences, a series for many nights in succession with quite as much correctness as if entire quantities had been used; for in that case he has only to calculate the elements for the first night, and substitute for the value of $d\,b$ the increment or decrement of polar distance, the other terms being virtually constant.

It has always, however, been an evil complained of in operations of this kind, that by limiting the case to the actual time of maximum Azimuth, the powers of the observer are much curtailed, because he cannot take more than one observation on the same night.

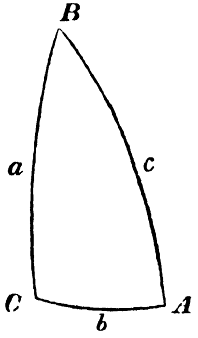
If observations, taken intermediately between the culmination and the time of the greatest Azimuth, were to be computed with reference to the meridian, it would be indispensable to employ large quantities, and the operose formulæ of Spherical Trigonometry, which would not only be laborious, but would not give so much accuracy as the method of eliciting the correction by means of differential terms.

I shall explain this better by a reference to the diagram in the margin, wherein the two Arcs ZS, ZS' are drawn very near to each other, the angle PSZ being a right angle, and it will be seen immediately how much more easily and accurately the angle PZS' may be found by computing the partial angle SZS', and deducting it from PZS, than by direct computation of the entire angle PZS' itself.



I have introduced, in the first part, the ordinary rules for computing the elements at the time of maximum, with the view that those, for whose use these formulæ are intended, may not need a reference to first principles, but have the subject in a complete state before them; and this must be my apology, should it be objected to me that I have presumed to intrude on the Society with propositions strictly elementary.

In any spherical triangle ABC if the sides b and c are constant, the sines of the angles B and C will attain their greatest values contemporaneously.



For the general equation is

$$\sin B = \sin C. \frac{\sin b}{\sin c}$$

in which the term $\sin B$ is obviously a maximum when $\sin C$ is a maximum; *i. e.* when $C = \frac{\pi}{2}$ or 90°.

If, therefore, A represent the Pole, B the Zenith, and C the place of a circumpolar star; when the Azimuth which is represented by the angle B is a maximum, the angle of position at C will be a right angle: in that case, therefore, we have

$$\text{1st. } \cos A = \tan b . \cot c \ldots\ldots (\alpha)$$

$$\text{2nd. } \sin B = \frac{\sin b}{\sin c} \ldots\ldots (\beta)$$

$$\text{3rd. } \cos a = \frac{\cos c}{\cos b} \ldots\ldots (\gamma)$$

But A represents the hour angle, or portion of sidereal space passed through between the instant of transit and that of maximum Azimuth;

c, the complement of the Latitude of the place of observation, or $c = \frac{\pi}{2} - \lambda$; b, the polar distance of the star; B the angle of Azimuth, and a the Zenith distance: consequently, if t' denote the seconds of sidereal time, the above equations are transformed to

1st. $\cos(15.t') = \tan$ ∗'s Pol. dist × $\tan\lambda$
2nd. $\sin$ ∗'s Azimuth $= \sin$ ∗'s Pol. dist × $\sec\lambda$
3rd. $\sin$ ∗'s Altitude $= \sec$ ∗'s Pol. dist × $\sin\lambda$

If t' be required in mean solar time, it must be diminished in the ratio of twenty-four hours to 23 H. 56 M. 4 S., or if τ' denote the seconds in mean solar time, then we have Log. τ' = Log. t' + Const. $\bar{1}\cdot9988127$.

The corrections are also easily obtained from tables constructed on purpose.

To take an example of this; let the time of the greatest Western Azimuth of the Pole-star be required on the 4th May, 1830, in Latitude 24° 0′ 0″, as also the Azimuth and Altitude at that instant; the Longitude being 78° East of Greenwich, and the Polar distance 1° 36′ 0″.

		Hour Angle.	Azimuth.	Altitude.
Pol. dist	1° 36′ 0″....	*tan* 8,4461103....	*sin* 8.4459409....	*sec* 0.0001694
Lat.	24° 0′ 0″....	*tan* 9,6485831....	*sec* 0.0392698....	*sin* 9.6093133
Space	89° 17′ 14.″8	*cos* 8.0946934	*sin* 8.4852107	*sin* 9.6094827
			1° 45′ 5.″37	24° 0′ 35.″83.

4
5 57 8.98 Siderial time. Refraction + 0 2 9.83.

22 16 3.19 *A.R* (∗ — ⊙) at noon.

Appt. Altde 24 2 45.66.

16 18 54.21 Sid. time
— 2 40.37 Corr^{n}.
16 16 13.84 Mean Solar Time

Hitherto the two sides b and c have been supposed to be correctly known, but it is not an unusual occurrence that a series of observations is computed for many nights by anticipation, with a Latitude merely approximate, and that when this element comes to be finally determined, corrections must be applied to obviate the effects of errors which may thus have been introduced.

To find these corrections, we must differentiate the equations (α), (β), (γ), with respect to c; whence we obtain

$$\text{1st.} \quad -\sin A.\, dA = -\frac{\tan b}{\sin^2 c}.\, dc = \frac{\tan b}{\sin^2 c}.\, d\lambda$$

$$\therefore \; -dA = \frac{\tan b}{\sin A.\, \sin^2 c}.\, d\lambda = \frac{\tan b}{\sin a.\, \sin c}.\, d\lambda$$

$$\text{Whence} \; -dA = \frac{\tan B}{\sin c}.\, d\lambda = \tan B.\, \sec \lambda.\, d\lambda.$$

$$\text{2nd.} \; \cos B.\, dB = \frac{-\sin b.\, \cos c.\, dc}{\sin^2 c.} = -\sin B.\, \cot c.\, dc$$

$$\therefore \; dB = \text{tang } B.\, \text{tang } \lambda.\, d\lambda$$

$$\text{3d.} \quad -\sin a.\, da = \frac{-\sin c.\, dc}{\cos b}$$

$$\therefore \; da = \frac{\sin c}{\sin a.\, \cos b}.\, dc = \frac{dc}{\sin A.\, \cos b}$$

$$\therefore \; -da = \frac{d\lambda}{\cos B} = \sec B.\, d\lambda$$

To show the application of these formulæ, let it be supposed that the parts of the triangle of greatest Azimuth had been computed previously for some nights in succession, with a Latitude deduced from an approximate series of triangles, and that instead of 24° 0′ 0″, as supposed in the last example, the Latitude was found to be 24° 1′ 45″. Then the operation will stand as follows :

	Hour Angle.	Azimuth.	Altitude.
d λ = 105″	Log .... 2·02119	.... Log 2.02119	.... Log 2.02119
B = 1° 45′	Log tan $\bar{2}$·48541	.... Tan 2.48541	.... Sec 0.00020
λ = 24° 0′ 0″	Sec 0.03927	.... Tan $\bar{1}$.64858	....
15 A. C.	Log 8·82391		
Corrections...... 0·″23	Log .... 1·36078	1.″43..Log 0·15518	1′ 45.″05 .. Log 2·02139
	H. ′ ″		
1st Computn...	16 16 13·84	1 45 5. 27	.... 24 2 45· 06
	H. M. S.	° ′ ″	
Correct values	16 16 13·61	1 45 6, 70	.... 24 4 30· 71

It will also sometimes happen in practice, that a series of observations, computed with data drawn from an imperfect catalogue of former years, requires to be corrected in conformity with the superior accuracy obtained by modern observers. In that case we must differentiate the same equations (α) (β) (γ) with respect to the Polar distance *b*, whence we obtain

$$\text{1st} - \sin A . \mathrm{d} A = \frac{\cot c}{\cos^2 b} . \mathrm{d} b$$

$$\therefore - \mathrm{d} A = \frac{\cot c}{\sin A . \cos^2 b} . \mathrm{d} b = \frac{\cos c}{\sin c . \sin A . \cos^2 b} . \mathrm{d} b$$

$$\text{Or} - \mathrm{d} A = \frac{\cos c}{\sin a . \cos^2 b} . \mathrm{d} b = \frac{\cos a}{\sin a . \cos b} . \mathrm{d} b = \cot a . \sec b . \mathrm{d} b$$

$$\text{2d} \cos B . \mathrm{d} B = \frac{\cos b . \mathrm{d} b}{\sin c}$$

$$\therefore \mathrm{d} B = \frac{\cos b}{\cos B . \sin c} . \mathrm{d} b = \frac{\mathrm{d} b}{\sin A . \cos \lambda}$$

$$\text{3d} - \sin a . \mathrm{d} a = \frac{\cos c . \sin b . \mathrm{d} b}{\cos^2 b}$$

$$\therefore - \mathrm{d} a = \frac{\cos c . \sin b}{\sin a . \cos^2 b} . \mathrm{d} b = \cot a . \tan b . \mathrm{d} b .$$

These formulæ, computed similarly to the former examples, will stand as follow. Suppose that (instead of 1° 36′) the polar distance had been 1° 35′ 34″, but that all the observations had been already computed with the former of these values. Then we shall have $d\,b = -26''$

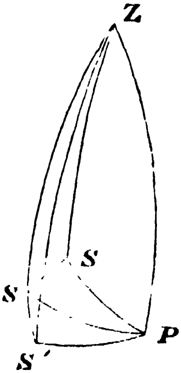
$d\,b = -26''$	Log 1.41497	Log 1.41497	Log $\bar{1}$.41497
$b = 1°\ 36'\ 0''$	Sec 0.00017		Tan 2.44611
$\left(\frac{\pi}{2} - a\right) = 24°\ 0'\ 36''$	Tan $\bar{1}$.64878		Tan $\bar{1}$.64878
15 A. C. Log	$\bar{2}$.82391		
A =		Cosec. 0.00003	
λ =		Sec 0.03927	
Corrections,	0.77 .. Log $\bar{1}$.88783	28″.46 .. Log 1.45427	0″.32 .. Log $\bar{1}$.50986
1st. Compd. values,	16 16 13.84	1° 45′ 5 .37	24 2.45.66
Correct values,	16 16 14.61	1° 44′ 36.91″	24 2.45.34

In these computations, the correction is applied to the altitude with an opposite sign to that resulting from the formulæ, as due to the zenith distance, the rationale of which will be evident. The formulæ will evidently shorten such operations considerably, because there is no necessity for more than five places of decimals, unless the variations are very large, and thus, if we retain all the quantities but the variation of *b*, we may compute a set of observations for many nights in succession, by merely finding the variations which are occasioned in the other parts.

In the work on the great Meridional Arc of India, which the Court of Directors did me the honor to have printed, the principle is examined (vide page 89,) of determining for how long periods some of the principal circumpolar stars of the Greenwich Catalogue may be considered as stationary in Azimuth; and it is therein shewn that, during the 2′ 3.″6 preceding and subsequent to the Maximum, the variation in Azimuth of the Pole Star is only 0.″25, a quantity less than the powers of our best instruments can be considered capable of detecting under ordinary circumstances—similarly β Ursæ Minoris and β Cephei, the two stars in former editions of the Nautical Almanack nearest the Pole, have $1' \, 23''$ and $1' \, 12''$ for their stationary periods.

It must, however, be remarked, that the hypothesis on which that enquiry is conducted, is not rigorous; for it is therein taken for granted that the same vertical circle will pass through the upper and lower positions of the star at equal lapses of time before and after the Maximum, an assumption which, though perfectly admissible for the end therein proposed, will not bear to be much extended: as for instance, suppose it were required to determine what would be the effect on the Azimuth, if instead of the precise instant of the Maximum, the observation were made at any time before or after that phenomenon.

To this end let PSZ be the polar triangle right angled at S, and let S' be the place of a star before or after arriving at S—Draw the Arcs of great Circles PS', SS', ZS', and then since PSS' is Isosceles, if a perpendicular were drawn from P on SS' it would divide that side, and also the angle at P into two equal and similar parts, so that if δP, δZ denote the variations of the hour angle and Azimuth, we have



$$\text{1st.} \quad \text{Tan } PSS' = \text{Cot } \tfrac{1}{2} \, \delta P \text{ Sec } PS$$
$$\text{2d.} \quad \text{Sin } \tfrac{1}{2} \, SS' = \text{Sin } \tfrac{1}{2} \, \delta P \text{ Sin } PS$$

Hence, because of the right angle at S, we have $\sin ZSS' = \cos PSS'$ and $\cos ZSS' = \pm \sin PSS'$ and therefore the general equation becomes (vide Woodhouse's Trigon. page 157—3d edition).

$$\tan \delta Z = \frac{\cos PSS'}{\cot SS' . \sin ZS \mp \sin PSS' . \cos ZS}$$

But $\cos ZS = \frac{\cos PZ}{\cos PS} = \frac{\sin \lambda}{\cos PS}$

And $\text{tang } ZS = \frac{\cos Z}{\cot PZ} = \frac{\cos Z}{\tan \lambda}$

$$\therefore \sin ZS = \frac{\cos Z . \cos \lambda}{\cos PS}$$

Consequently $\tan \delta Z = \frac{\cos PSS' . \cos PS}{\cot SS' . \cos Z . \cos \lambda \mp \sin PSS' . \sin \lambda}$

$$= \frac{\cot PSS' . \cos PS}{\sin \lambda} . \frac{1}{\frac{\cos Z}{\tan SS' . \tan \lambda . \sin PSS'} \mp 1}$$

$$= \frac{\cos^2 PS . \tan \frac{1}{2} \delta P}{\sin \lambda} . \frac{1}{\frac{\cos Z}{\tan SS' . \tan \lambda . \sin PSS'} \mp 1}$$

Where the upper sign is used, when the star is nearer the Zenith, and the lower, when it is further removed from the Zenith than in the position of maximum.

If in the former of these cases, which occurs in the Western Elongation before, and in the Eastern after ariving at the maximum, we put

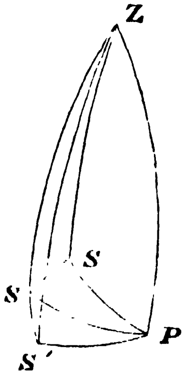
$$\left(\frac{\tan SS' . \tan \lambda . \sin PSS' .}{\cos Z} \right)^{\frac{1}{2}} = \sin \theta$$

Then $\tan \delta Z = \frac{\cos^2 PS . \tan \frac{1}{2} \delta P}{\sin \lambda} . \tan^2 \theta$

Or $\delta Z = \frac{\cos^2 PS . \tan \frac{1}{2} \delta P . \tan^2 \theta}{\sin \lambda . \sin 1''}$ in seconds of a great circle circumstances—similarly β Ursæ Minoris and β Cephei, the two stars in former editions of the Nautical Almanack nearest the Pole, have 1' 23' and 1' 12' for their stationary periods.

It must, however, be remarked, that the hypothesis on which that enquiry is conducted, is not rigorous; for it is therein taken for granted that the same vertical circle will pass through the upper and lower positions of the star at equal lapses of time before and after the Maximum, an assumption which, though perfectly admissible for the end therein proposed, will not bear to be much extended: as for instance, suppose it were required to determine what would be the effect on the Azimuth, if instead of the precise instant of the Maximum, the observation were made at any time before or after that phenomenon.

To this end let *PSZ* be the polar triangle right angled at *S*, and let *S'* be the place of a star before or after arriving at *S*—Draw the Arcs of great Circles *PS'*, *SS'*, *ZS'*, and then since *PSS'* is Isosceles, if a perpendicular were drawn from *P* on *SS'* it would divide that side, and also the angle at *P* into two equal and similar parts, so that if δP, δZ denote the variations of the hour angle and Azimuth, we have



$$\text{1st.}\quad \text{Tan } PSS' = \text{Cot } \tfrac{1}{2}\,\delta P \text{ Sec } PS$$
$$\text{2d.}\quad \text{Sin } \tfrac{1}{2}\, SS' = \text{Sin } \tfrac{1}{2}\,\delta P \text{ Sin } PS$$

Hence, because of the right angle at *S*, we have $\sin ZSS' = \cos PSS'$ and $\cos ZSS' = \pm \sin PSS'$ and therefore the general equation becomes (vide Woodhouse's Trigon. page 157—3d edition).

EXAMPLE.

To find *Tan* PSS' and *Sin* PSS'

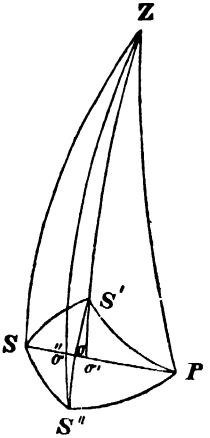
$\frac{1}{2}\delta P$ (= 15′ in time) = 3° 45′ 0″	L. *Cot*	1.1834706
PS = 1° 36′ 0″	L. *Sec*	0.0001694
PSS'	L. *Tan*	1.1836400
	L. *Sin*	9.9990698

To find *Sin* $\frac{1}{2}$ SS' and *Tan* SS'

$\frac{1}{2}\delta P$ = 3° 45′ 0″	L. *Sin*	8.8155985
PS = 1° 36′ 0″	L. *Sin*	8.4459409
$\frac{1}{2}SS'$	L. *Sin*	7.2615394
3. *Corr^n*	L. *Sec*	0.0000021
	Log of 2	0.3010300
SS'	L. *Tan*	7.5625715
Sin Z = 8.4852107	L. *Sec*	0.0002028
λ = 24° 0′ 0″	L. *Tan*	9.6485831
	2)	7.2104272

8.6052136	L. *Tan*	θ' / θ	L. *Sin*	8.6052136
0.0003528	L. *Sec*		L. *Sec*	0.0003528
8.6048608	L. *Sin*		L. *Tan*	8.6055664
9.9998306	L. *Cos* PS		L. *Cos*	9.9998366
8.6046914				8.6053970
7.2093828	*Double*		*Double*	7.2107940
8.8165294	L. *Tan* $\frac{1}{2}\delta P$		L. *Tan*	8.8165294
0.3906867	L. *Cosec* λ		L. *Cosec*	0.3906867
5.3144251	A. C. L. *Sin* 1″		A. C. L. *Sin*	5.3144251
1.7310240	Log. 53″·830		54″·005 Log.	1·7324352
Value of δZ below.			Value of δZ above.	

It will now be in place to explain how the above formula can be simplified, to which purpose let S', S'' be two positions of a circumpolar star at equal lapses of time before and after the maximum, so that the angles at P. viz. SPS', SPS'' may be equal to each other; then if the diagonal $S'\,S''$ of the Quadrilateral formed by the pole and the three positions of the star be drawn, it will intersect the other diagonal PS at right angles in σ and the two vertical circles ZS', ZS'' (produced in the former case) will intersect the great circle PS obliquely in two points σ', σ'' making two very small triangles $S'\sigma\sigma'$, $S''\sigma\sigma''$, each equal and similar to the other and right angled at σ. Now in $\Delta\, ZS\sigma'$ which is right angled at S, if we denote as before by δZ the variation or $SZ\sigma'$, we have



1st $\sin SZ = \cot \delta Z.\ \tan S\sigma'$; or $\tan S\sigma' = \sin SZ.\ \tan \delta Z$

$\therefore\ S\sigma' = \sin SZ.\ \delta Z = \sin P.\ \cos\lambda.\ \delta Z \ldots\ldots\ldots\ (\alpha)$

2d $\cos \sigma' = \sin \delta Z.\ \cos SZ$

$$\therefore\ \left(\frac{\pi}{2} - \sigma'\right) = \cos SZ.\,\delta Z;\ \text{and}\ \sigma' = \frac{\pi}{2} - \cos SZ.\,\delta Z$$

3d $\therefore\ \sigma S'\sigma'$ or $\angle\ S' = \cos SZ.\ \delta Z$ ———————— (in $\Delta\ S'\sigma\sigma'$)

And since $\tan \sigma\sigma' = \sin S'\sigma.\ \tan S'$

Therefore $\sigma\sigma' = S'\sigma.\ \cos SZ.\ \delta Z \ldots\ldots\ldots\ (\beta)$

Again in $\Delta\ PS'\sigma$ right angled at σ we have

1st $\cos \delta P = \cot PS'.\ \tan P\sigma$; but $\tan P\sigma = \tan(PS - S\sigma)$

$$\therefore\ \frac{\tan PS - \tan S\sigma}{1 + \tan PS.\ \tan S\sigma} = \cos \delta P.\ \tan PS$$

$$\therefore\ \tan PS - \frac{S\sigma}{\cos^2 PS} = \cos \delta P.\ \tan PS$$

$$\therefore\ S\sigma = \tan PS.(1 - \cos\delta P).\cos^2 PS = \sin 2\,PS.\sin^2\tfrac{1}{2}\delta P \ldots\ldots (\gamma)$$

2nd $\text{Tan}\ S'\sigma = \sin P\sigma.\tan\delta P = \sin(PS - S\sigma).\tan\delta P$

$$\therefore\ S'\sigma = (\sin PS - \cos PS.\,S\sigma).\tan\delta P$$

Or $S'\sigma = \sin PS.\tan\delta P.(1 - \cot PS.\,S\sigma)$

$$= \sin PS.\tan\delta P.(1-2.\cos^2 PS.\sin^2\tfrac{1}{2}\delta P)\ldots\ldots\ldots\ldots\ldots\ldots\ldots (\iota)$$

Combining now the equations (β) and (ι) we obtain

$$\sigma\sigma' = \sin PS.\tan\delta P.(1-2.\cos^2 PS.\sin^2\tfrac{1}{2}\delta P)\cos SZ.\,\delta Z$$

$$= \tan PS.\sin\lambda.\tan\delta P.(1-2.\cos^2 PS.\sin^2\tfrac{1}{2}\delta P).\,\delta Z.\ldots\ldots\ldots (\zeta)$$

(because $\cos ZS = \dfrac{\cos PZ}{\cos PS} = \dfrac{\sin\lambda}{\cos PS}$)

and this value of $\sigma\sigma'$ answers for both the upper and lower positions, being subtractive in the former, and additive in the latter, with respect to the mean distance $S\sigma$.

We have, therefore, generally
$S\sigma = S\sigma' \mp \sigma\sigma'$ ...... in which, by substituting the values given in Equations (γ) (α) (ζ) we get

$$\text{Sin}\ 2\,PS.\sin^2\tfrac{1}{2}\delta P = (\sin P.\cos\lambda \mp \tan PS.\sin\lambda.\tan\delta P.(1-2.\cos^2 PS.\sin^2\tfrac{1}{2}\delta P)).\,\delta Z$$

$$\therefore\ \delta Z = \frac{\sin 2\,PS.\sin^2\tfrac{1}{2}\delta P}{\sin P.\cos\lambda.\left\{1 \mp \dfrac{\tan PS.\tan\lambda.\tan\delta P.(1-2.\cos^2 PS.\sin^2\tfrac{1}{2}\delta P)}{\sin P}\right\}}$$

$$= \frac{\sin 2\,PS.\sin^2\tfrac{1}{2}\delta P}{\sin P.\cos\lambda.(1 \mp \cot P.\tan\delta P.(1-2.\cos^2 PS.\sin^2\tfrac{1}{2}\delta P))}$$

Or $\delta Z = \dfrac{\sin 2\,PS.\sin^2\tfrac{1}{2}\delta P}{\sin 1''.\sin P.\cos\lambda}.(1 \pm \cot P.\tan\delta P)$ nearly.

Whence $\text{Log}\,\delta Z = \text{Log}\sin 2\,PS + 2.\ \text{Log}.\sin\tfrac{1}{2}\delta P + \text{Log}.\text{cosec}\ P + \text{Log}.\sec\lambda + \text{A.C. Log}.\sin 1'' \pm M.\cot P.\tan\delta P$. .... Where M denotes the number 0.4342944819, &c. whose Log is 9.6377843, the upper or lower sign being used according as the star is above or below the maximum.

The nature of this last substitution has been shewn in my work on the measurement of an Arc of the Meridian (Page 61) and is simply thus.

$$\mathrm{d}\,(\text{hy.}\log(1 \pm x)) = \frac{\pm\,\mathrm{d}\,x}{1 \pm x} = \pm\,\mathrm{d}\,x.\,(1 \mp x + x^2 \mp x^3 + \&\text{c.})$$

$$\therefore\ \text{hy.}\log(1 \pm x) = \pm\,(x \mp \frac{x^2}{2} + \frac{x^3}{3} \mp \frac{x^4}{4} + \&\text{c.})$$

$$\therefore\ \text{Log}\,(1 \pm x) = \pm\,M x.\,(1 \mp \frac{x}{2} + \frac{x^2}{3} \mp \frac{x^3}{4}\ \&\text{c.})$$

in which, when x is very small, the series converge so rapidly that all terms but the first may be omitted, and we get merely

$\text{Log.}\ (1 \pm x) = \pm\,M x.$

Therefore $\text{Log.}\ (1 \pm \cot P.\,\tan\delta P) = \pm\,M.\cot P.\,\tan\delta P.$

Taking now the elements as in the first of the above instances, viz.

$PS = 1^\circ\ 36'\ 0''$; $\delta P = 30'$; $P = 89^\circ\ 17'\ 14''.8$; $\lambda = 24^\circ\ 0'\ 0''$

the computation will be as follows:

To find $M.\cot P.\,\tan\delta P$

9.63778
9.11943 *Tan.* 7° 30′
8.09472 *cot* P
6.85193 Log. of . . . . ∓ 0.0007111
$2\,PS = 3^\circ\ 12'\ 0''$ . . Log. *Sin.* 8.7468015
$\frac{1}{2}\,\delta P = 3^\circ\ 45'\ 0''$ . . 2 Log. *Sin.* . . 7.6311970
P Log. *Cosec* 0.0000336
$\lambda = 24^\circ\ 0'\ 0''$ Log. *Sec* 0.0392698
Ar. Co. Log. *Sin* 1′ 5.3144251
δZ above 54″. 005 . . . . 1.7324381
δZ below 53″. 829 . . . . 1.7310159

The above computations will shew that the approximate method may be quite as much relied on as the more elaborate one, and it will appear on pursuing the enquiry that, for about thirty-two minutes prior and an equal lapse subsequent to the maximum, the Polar Star only varies one minute of space in Azimuth in the latitude of 24° 0′ 0″.

V.

MEMORANDUM
ON
THE FOSSIL SHELLS
DISCOVERED IN THE HIMALAYAN MOUNTAINS.

BY THE REV. R. EVEREST.

I HAVE ventured to say a few words respecting the Fossils sent down from the *Himalaya* mountains, by Dr. GERARD, because nobody else is about to do so; and it is a pity that they should remain unnoticed.

In doing this, I shall make no remark upon the general difficulty of identifying fossil shells with recent genera, as that is well known to any one who has ever attended to the subject. But to one who lives at a distance from means of reference, such a difficulty is greatly increased, since, in many cases, he must speak from recollection alone. Upon this ground I must plead for the indulgence of my hearers towards such imperfections as they may observe in this paper—my purpose in entering upon a branch of Geology, not the most familiar to me, will have been answered, if I can induce others to join in a pursuit, which circumstances will no longer permit me to continue.

To begin, then, with the specimens before us, in the relative order of their abundance, we have—

1. *First.* Numerous blocks of a compact greyish silicious limestone, (in some parts passing to sandstone), filled with shells and casts of a small inequivalve, eared bivalve, which do not appear to differ from the small Pecteus imbedded in the lias blocks from the Coast of Yorkshire, which we owe to the liberality of Mr. TAYLOR. The shells themselves are changed to a black colour as they are in that formation. As they are mostly mutilated, it is not improbable that other genera may hereafter be distinguished among them. One such I have recognized— a very transverse bivalve, not unlike Unio, in external shape—but, as I could only find one cast of it, I have not attempted to give it a name—with this genus of Pecteus must be ranged two mutilated specimens, which we have in a dark bluish black limestone, and which are only a variety—possibly only the same shell in a more advanced stage of growth—The generic marks are wanting, but by comparing them with a beautiful English specimen of Mr. TAYLOR's, no doubt can remain as to their identity.

2ndly. Many specimens of an inequivalved bivalve, which has been changed into a white crystalline substance, and from its hardness probably contains much silex. They are imbedded in a hard slate of the same bluish black colour, which is covered with small scales of mica—They appear to belong to the genus Producta, and may be compared with a specimen of the same genus, the Producta Scotica, in Mr. CALDER's collection, and a plate of the same in URE's Geology. They differ somewhat from this species by the greater flatness of the lower valve; but as most of the specimens have suffered from compression, it is difficult to ascertain what has been their natural shape. Besides the larger and more abundant variety of which we have been speaking, there is a smaller one, or rather some casts of one of its valves—the depression in it is large and deep, and towards the beak appears some trace of a perforation and its operculum.

3rdly. Several pieces of a bluish grey limestone, abounding in a plaited variety of Terebratula, and loose specimens of the same. The limestone has imbedded in it some calc spar of a yellowish white colour, and is partly covered with a yellowish earthy powder, of the colour we see in the oolitic countries. The shells themselves differ little from those which are so abundant in the inferior oolite near Bath and elsewhere, and which may be referred to in Mr. CALDER's collection—but without Mr. SOWERBY's Mineral Conchology to refer to, it is impossible to add the specific name. These blocks also contain No. 1.

4thly. Many specimens of an equivalve transverse bivalve, transversely striated, and the valves crenulated on their interior margin. Its external shape is similar to that of a short variety of Unio, to which it has been referred, but internally it has no lateral teeth, nor any remnant of a lateral ridge; and though the specimens we have are too much worn to shew what the teeth really were, they appear to have been situated directly under the beak. Its flattened and acute beaks, and form approaching to that of a variety of fossil Trigonia of Mr. CALDER's, once made me incline to reckon it with that genus. Its shape too a good deal resembles a Venus, but its characters are not satisfactorily made out, and I have not access to any plate or specimen with which I can identify it. With these are some larger specimens of a triangular or rather suborbicular bivalve, which, in external shape, resembles a Venus or perhaps a Donax, but the characters are not distinct enough for me to venture to give it a name.

5thly. Several small very transverse equivalved bivalves, about three-fourths of an inch in length, and of a black colour, they appear to be of the genus Modiola.

6thly. Two small specimens of a variety of Arca.

7thly. Several specimens of Ammonites in black limestone, sometimes filled inside with calcareous spar. There is but one species distinguishable, which appears to differ little, if at all, from one of the English ones of Mr. TAYLOR; but unfortunately I cannot refer to any book for the specific name.

8thly. Belemnites—the furrow appears to be rather more distinctly marked than in the English ones.

9thly. Orthoceratites, which do not appear to differ from the English ones.

10thly. A cast of a Patelliform shell—but whether one of the real Patellæ, or the upper valve of one of those species of bivalves, which have sometimes been confounded with them, we have no means of determining. Its shape is conical, and somewhat obliquely curved.

11thly. Two fragments of the back of a testudinous animal, also in black limestone.

We have, then, genera determined—of

BIVALVES.	UNIVALVES.
Producta.	Ammonites.
Terebratula.	Orthoceratites.
Pecten.	Belemnites.
Modiola.	
Arca.	
	Total,.... Three Genera.

Altogether,......... 5
Undetermined,..... 4
Total,....... 9

Testudinous remains of one kind.

Let us now see to what conclusions these genera will lead us.

The three Chambered Univalves are all extinct genera, and the Nautilus, the only living analogue to the Ammonite, is wanting.

Of these, the Orthoceratite has usually been considered the oldest, and characteristic of the so-called transition strata.

The Ammonite comes next in age, and occurring sparingly in the transition strata, is deposited most abundantly in the Lias, and the other more ancient of the secondary strata; then becoming more and more rare, as we advance to more recent deposits, it finally disappears in the strata above the chalk, that go by the name of Tertiary.

The species we have, though apparently coinciding with one of Mr. TAYLOR's from the Lias of Yorkshire, is not one of those which has the siphuncle in a raised ridge between two furrows, which are considered as characteristic of this formation. I have several times looked for such among the Salagrams in the *Hindoo* temples, but without success.

The Belemnite is found from the Lias to the Chalk, both inclusive.

On the other hand, the Spiral Univalves, which increase both in number and variety as we approach the more recent formations, are with us totally wanting, nor have we as yet any other indications of such formations.

Of the bivalves, the Producta is considered as the oldest genus, and is most abundant in the transition formation. The slate in which it is imbedded, is probably, therefore, a transition slate—the same which is the repository of the Orthoceratite.

The Terebratula, if not identical in species with those of Mr. Calder, from the lower Oolite, is very similar to them, and totally unlike any from the newer formations.

The Pectens, at least the larger variety, do not appear to differ from the common Scallop which is found recent.

The shell I have called Trigonia, cannot be compared with any fossil specimens we have. The genus is, with one exception, a fossil one.

The generic characters of the Arca and Modiola, are tolerably well marked; but we have neither plate nor specimen from which to identify the species. They are not, however, important.

The testudinous remains seem to point to the Lias, or some of the secondary strata, that being the deposit in which the remains of reptiles occur most abundantly. In strata more ancient than that, they are nearly (if not quite) wanting. It is to be hoped that the spot where these two fragments were found, will be again diligently searched—we must forbear from indulging in too sanguine anticipations but such a search can hardly fail of rewarding us with some interesting discoveries.

Now, if we consider the Orthoceratite and Producta, as peculiar to one formation, and the rest of our specimens to another, (the Terebratula, perhaps, being common to both) and compare them with the list of Lias fossils, we have,—of Chambered Univalves—two genera the same, out of four, viz. Ammonites and Belemnites—of Bivalves, four genera the same out of eighteen; viz. Terebratula, Pecten, Arca, Modiola. We may now then consider this position as established. That *there exist, in the Himalaya range, strata analogous to the early secondary and transition* *formations of Europe*. How far that analogy may be complete or not, must be left to future investigation. But the wonderful similitude which has, as yet, obtained in fossils from different parts of the world, leads us to hope that the principal members of each group will be hereafter supplied. While we are on the subject, however, we cannot so well estimate the real amount of progress we have made in the question, as by recapitulating, on the other hand, the leading names in each division, which are as yet wanting to us.

We have nothing either of Encrinal or Coralline remains, which are so abundant in the transition rocks of Europe, that their absence here seems remarkable. We have none of the extinct order of Trilobites, the presence of which is peculiar to transition rocks.

We have no remains of the two vast marine lizards, the Icthyosaurus and Plesiosaurus, the bones of which every where mark the presence of Lias, and (I speak from authority in saying) without the discovery of which, we must not attempt to use the term Lias in Indian Geology. We have neither of the three shells, the Ammonites Bucklandi, the Plagiostoma Gigantea, and the Gryphœa Incurva, which are also considered as characteristic of that formation—nor have we any of its vegetable remains, which are both numerous and interesting.

I must now again beg to be excused for the imperfections of this paper, and the great length to which it has been extended.

NOTE.—Since the above was written, SIR CHARLES GREY has kindly put into my hands some specimens he has just received from the same quarter—Mr JAMES PRINSEP has also favoured me in a similar manner.—They are as follows:

1st. The two former varieties of the shell I have called Producta—a third, which can hardly be said to differ from the Producta Scotica—besides what appears to have been the larger valve of an inequivalved Bivalve resembling Producta—the hinge straight linear; the shell marked with longitudinal furrows and ridges, and a deep depression, as in that genus, but at the beak is a large angular sinus, with what appears to have been an operculum, and ligament protruding—Spirifer ?

2dly. Terebratulites, the same as the others, and at least two new varieties—both of the plaited kind.

3dly. Repetitions of the Bivalve, I have before spoken of under the third head.

4thly. Another impression of the same patelliform shell, as before mentioned.

5thly. Three broken pieces of a Bivalve shell, greatly resembling the Inoceramus, for which I beg to refer to the plates in CUVIER.

6thly. Two casts of Spiral Univalves, which appear to be Cirrus and Helix. The first may be compared with a Cirrus from the chalk, and another from the Oolite formation in Mr. CALDER'S collection, so that no doubt can well be entertained as to the name.—The one I have called Helix resembles the elongated variety, which is called Helix vivipara. It may be compared with the casts in a piece of Petworth marble, which we have. But there are other genera to which it may be ascribed—perhaps Turbo, for one of them.

7thly. Two small varieties of Ammonites, both much worn, and we have nothing to refer to for the specific name. One of them has the Siphuncle in a raised ridge at the back There is also an imperfect cast of another variety, which hardly differs from one we have from Mr. TAYLOR, and named in his list as Ammonites Planicosta. We have then here three additional genera, Cirrus, Helix, and Inoceramus (?)—besides a multitude of broken and worn impressions of the genera before described, with many nodules of what I believe to be clay ironstone; but I have not yet had time to examine them sufficiently.

Dr. FALCONER has found the specific gravity of some of these nodules to be 3·00, or nearly so; one or two that we have broken, have shewn us Ammonites covered with a thin coating of Pyrites. It would always be better for Collectors to split these nodules as carefully as possible, when they are found, instead of sending them down whole.

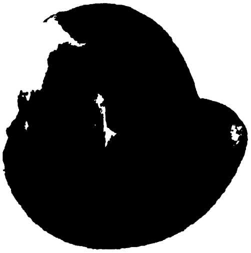
REFERENCE TO PLATES I. AND II. OF HIMALAYAN FOSSIL SHELLS.

Figure 1. Orbulite. Fig 2 Ammonite. Fig. 3. Ditto. Fig. 4. Orbulite. Fig. 5. Ammonite. Fig. 6. Ammonite. Fig. 7. Orbulite. Fig. 8. Helix or Turbo ? This Shell is represented rather too large in the drawing. Fig. 9. Oobulite. Fig. 10. Cast of a Patelliform Shell. Fig. 11. a, b, Cirrus. Fig. 12 Turrittella ? Fig. 13. Undetermined. Fig. 14—15. Orthoceratites. Fig. 16—17. Belemnites. Fig. 18. Fragment of a Testudo Fig. 19. Fragment of Rock, containing small mutilated Pectens and other genera imbedded. Fig. 20—21. Pectens. Fig. 22—23. Producta. Fig. 24. Terebratula. Fig. 25. Spirifer ? Fig. 26. a, b, c, d, The supposed Unio. Fig. 27. Arca. Fig. 28. a, b, and c, Modiola. Fig. 29. Fragment of an Inoceramus ?

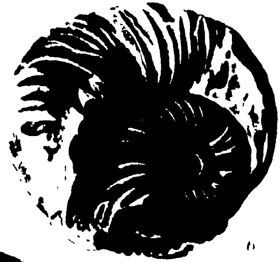
Himalayan Fossil Shells.

UNIVALVES.

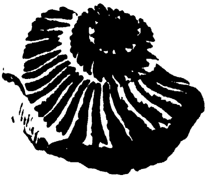
1



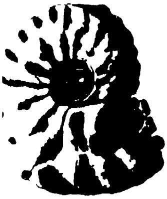
2



3

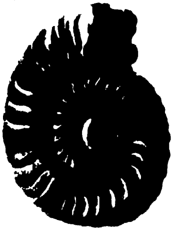


4

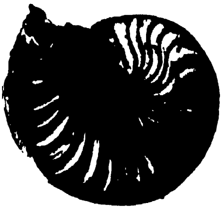


5

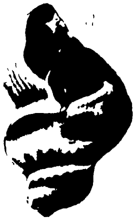
6

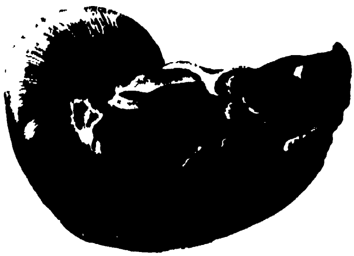


7

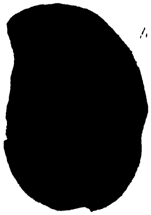


8

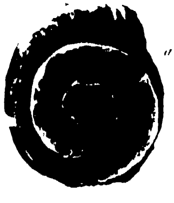


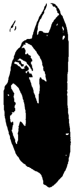


10

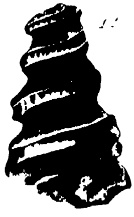


11

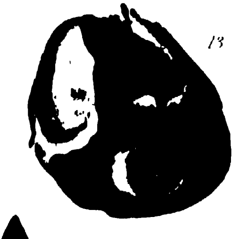




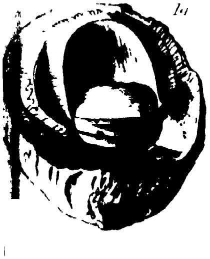
12

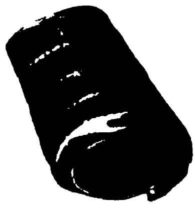


13

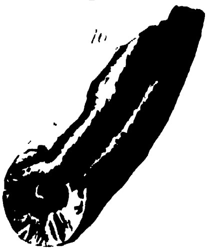


14

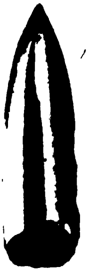




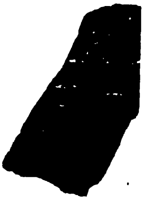
16



17



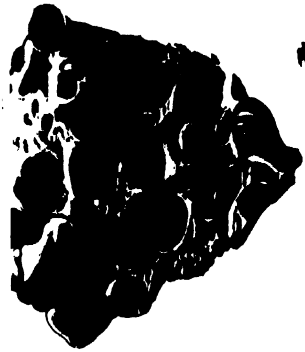
18



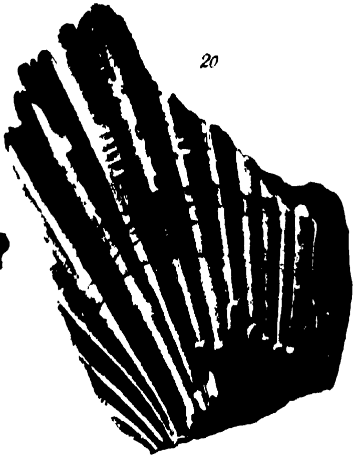
Nasmyth

Himalayan Fossil Shells.
BIVALVES

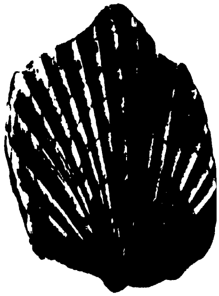
19



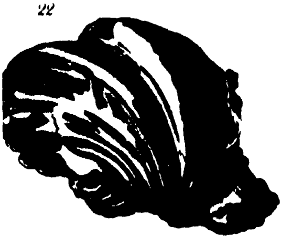
20



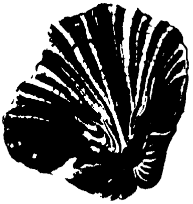
21



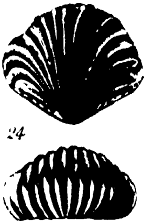
22



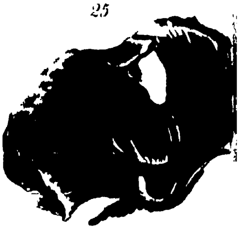
23



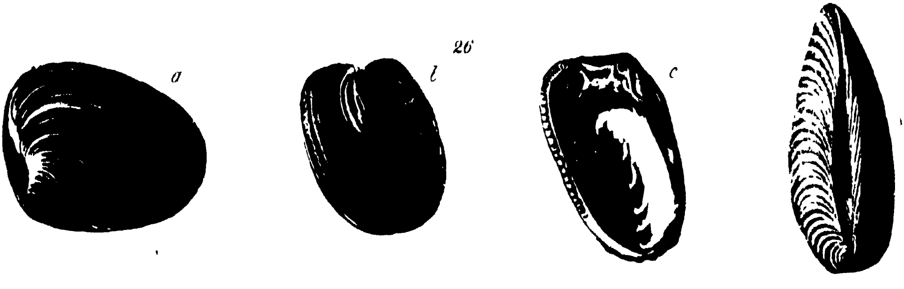
24



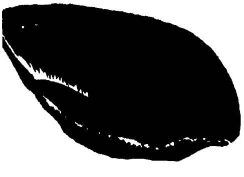
25



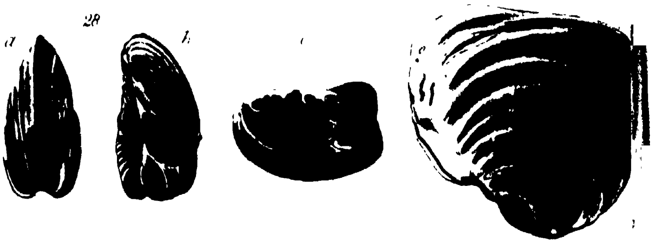
26



27



28



'rangp del.

Kasnath

VI.

ON THE

GEOLOGY OF THE PENINSULA.

By LIEUT. S. CHARTERS MACPHERSON,

Madras Survey Department.

The mountain groups of the Indian Peninsula, which are referrible in their immediate connections to either line of Ghauts, may, in the comprehensive assignment of relations, be regarded as the continuation of the branches, which, depending from the *Himalayan* chain, merge in the plains of the *Ganges* and of *Sinde* respectively. And apart from considerations of geographical analogy, the region which declines on the north of the *Kistna*, from *Hydrabad* towards the *Coromandel* shore, bears similitudes in superficial character to the mountain lines to which it claims affinity. This tract of the eastern declension of the Peninsula is Primary; and as the overlying formation which proximately succeeds it to the Westward, prevails thence continuously to the opposite coast, it presents complete, the series of that division displayed in this parallel. Its plane is eminently traversed by the three hilly ranges of *Hydrabad*, *Condapilly*, and *Beizwarra*, which, with a general north-westerly direction, tend to convergence to the southward. And of these, the Granitic district, with its subordinates, embraces the first, extending to the rise of the

Gneiss facade, which forms the western exposure of the second. The gneiss tract passing to quartz rock, the latter alone constitutes the eastern quarter of the *Condapilly* cluster, while the final range of *Beizwarra* displays an extended deposit of argillaceous schist. The granitic region exhibits in external configuration the ordinary classes of unstratified forms, but with diffuse variations in mineral character, presents no determinate connections betwixt the elementary modifications, and those of arrangement in mass. The rocky environs of *Hydrabad*, chiefly assuming the concretionary structure in prisms, vertically superadded to the bedded form, afford in disintegration a wild assemblage of columnar and cubic fragments: while irregular masses, wasting with spheroidal contours, rise in the same vicinity in isolated mountain domes. The range appears boldly compacted beyond the plain of the *Moussy*, one of the numerous feeders of the *Kistna*, which here reticulate the land, and with slight elementary alteration, a laminal tendency is there combined with the bedded structure. The rock is of quartz and felspar, and usually porphyritic by additional crystals of the latter, and the hue and lustre of the quartz communicate a reddish shade, while neither the rounded nor the prismatically fragmented characters continue eminent. In the course of an easterly transverse valley, the bedded masses persisting upon a cumbrous scale, the contours incline again to asperity and opake quartz, with hornblende, slightly diffused, predominates in the rock. Beyond *Singaveram* appear extensive masses of magnetic iron ore, now level with the granite of the valley, now irregularly emerging over it, and accompanied by beds of hornblende schist,* usual to this mineral in primary sites. The approach to *Malkapúr* is marked by a general retirement of the hills, and an abraded rock overhangs the hamlet as a large cupola upon the plain, alone affecting departure from the rugged outlines around ; and the transection of the range being here completed, its eastern flank extends with well-sustained elevation to the southward, presenting no marked deviation from the lately prevalent characters of form. Rare granitic elevations are scattered over the plain that succeeds, and beyond a tract of arid and incumbered wastes, the surface becomes less difficult, with altered vegetable characters : hornblende schist alternates with quartz rock in wide undulating courses, and around *Narhailpilly*, the granite is determined to crested summits, by the occasionally vertical disposition of its beds. Towards *Hytepámalí*, a surface simply granitic, recurs, and felspar predominates in the soil of *Soriapet*, while hornblende rock indistinctly stratified, and of massive texture, occasionally appears. The low, bald hills of *Mungal*, *Kamerabunda*, and *Godaveram*, slowly descending through laminar disintegration to the superficial level, are frequently pervaded by veins of jasper, becoming cancellated on exposure: the materials of the rock and vein frequently intermingle, but while fragments of the former appear isolated in the latter, both unaltered and in the grades of assimilation, the venous matter does not occur under reciprocal circumstances in the rock. In some instances also, through combination of the prismatic and bedded structures, the granitic surfaces in this district afford tabular aggregations of short vertical prisms, the rock varying in constitution betwixt gneiss and splintery hornstone. Immediately beyond the village of *Shair Mahomed Pet*, an extensive mass of Hornblende Schist is disposed in the great basis both in the manner of interference and of superposition : and a stream bed displays the course of an emanating vein in which the felspar, having by this accident of locality, passed to some depth to the state of indurated clay, this portion of the rock assumes the constitution and aspect of grey wacke, while the principal bed remains an unaltered greenstone. In the water-course were abundant fragments of compact red iron ore, rolled, with vitreous glaze, with occasional masses of calcareous tufa and of quartz, including crystals of white and flesh-red felspar, while the granite around deviates widely into constitutional irregularities. In the neighbourhood of *Nandigamah*, primary limestone, chlorite schist, and white sluty quartz rock appear. I could not ascertain the site in mass of the first, a clear limestone, laminated by argillaceous matter. The chlorite occurred foliated with laminar quartz, and scaly with greyish compact felspar and quartz · the former variety being of the usual splendent lustre, and occasionally tending to talcose schist. Beyond the village, hornblende and chlorite schists appeared in frequent alternation, and affording rich cotton moulds: the strata of hornblende were nearly vertical, while the inclination of the chlorite was under 70°; and a general conformity was maintained, amid the frequent intrusion of granitic veins, until approaching the western face of the *Condapilly* group, which rises boldly interchained near *Parteal:* these tracts are lost in an alluvial plain. The great alluvium of *Ellore*, extending betwixt the Deltas of the *Kistna* and the *Godavery*, here intervenes; and it exhibits a layer of superficial mould resting upon an uniform calcareous deposit which covers an apparently co-extensive bed affording the diamond, and in the neighbourhood of *Parteal*, formerly the most productive of the jewel-bearing spots of *Golconda*. The superficial mould is fifteen feet, the tufaceous bed being from five to six, and the diamond stratum of two feet in average thickness. The obscurity attached to the geognostical history of the diamond, seems rather to result from inadequate investigation in persistent geology, than from the perplexed texture of alluvial connections with which it is frequently associated. Its common matrix in *India* and *Brazil* appears to be a superior sandstone conglomerate, closely affined to the carboniferous rocks, and to this series the transported alluvia which afford the gem may be uniformly assigned. But while its rich depository in this tract does not essentially differ in constitution from the diamond rocks of either hemisphere, it is remarkable that the overlying tufaceous bed, in which the gem has never appeared, is identical with it in materials, only with the addition of calcareous cement. Pebbles of sandstone, hornstone, quartz, jasper, and flint, with fragments of occasional rocks, epidote, and abundant ferruginous sand constitute the common materials, while both the *Kistna* and its supplementary streams are extensively connected both with the gangue rock of the diamond, and with calcareous tracts. The western façade of the *Condapilly* range is of granitic gneiss, in which the ordinary ingredients are disposed in compact parallelism, and the strata inclined at an angle of about 75°. A detached mass displayed the intrusion of a vein of hornblende, into which the granitic matter entered in the filamentous form, and fragments of ochry iron ore appeared scattered on the surface. A double breach through this and the *Beizwarra* line of hills, here affords to the *Kistna* an escape towards the ocean, the farther chasm appearing in the outline of argillaceous summits. Along the northern base of the first intersection, the gneiss passes by the gradual demission of mica to quartz rock, and upon the side of *Condapilly* the range presents an aspect essentially different from that of its opposite quarter. The summits were there obtusely moulded, their contours broken or minutely serrated, and marked by projections of rifty cliff: the transverse valleys rare, and deeply channelled by mountain streams. Here the outlines are rounded upon scales of great radii. the fragmented aspect is wanting, and the mountain flanks are projected not in precipice or cliff, but in broad smooth convexities, the side shields broken by transverse steppes, and cumbered by dependant verdure. The quartz rock, of quartz and felspar, affords numerous varieties of white, reddish, and purpled hues. It is inclined at an angle somewhat more acute than the subjacent gneiss, while the presence and frequent predominance of garnets in the mass extensively modify its characters, and the alamandine or precious garnet, variously tinged, and of superior size and beauty, is found abundantly in the mountain torrents. The range of *Beizwarra* rises with soft outline beyond a succeeding plain. It consists of coarse and thickly fissile argillaceous schist, inclined in texture and stratification at angles of from 40° to 60°, and through the exuberant presence of unessential minerals, both venous and imbedded, it exhibits modifications of rich variety. The rock is sometimes simply constituted of argillaceous matter with mica and quartz sand: in other portions it is traversed in all directions by filamentous veins of pearl and calcareous spars, and through these often affects the minute contortions proper to gneiss, while veins of spathose iron, and of quartz rock, frequently occur, disposed indifferently to the lines of stratification. To the southward, at *Cottah Mangalagherry*, it embraces, at least from one quarter, an elevated and indistinctly stratified mass of serpentine, which sole example of this rock observed in India, I regret to say, remains unexplored; and assuming to the eastward a more uniform and finely schistose character, it sinks gradually to the ocean level, upon the whole affording the annexed constitutional and Mineral Synopsis.

---

* By this term varieties of Primitive Greenstone are conveniently comprehended.

1. Argillaceous Schist, schistose from the disposition of Mica and Garnets.
2. Argillaceous Schist, laminated by Pearl Spar and Staurolite.
3. Argillaceous Schist laminar, with pink Garnets, Staurolite, and Mica.
4. Argillaceous Schist with Staurolite, Tremolite, and Mica.
5. With Staurolite and Kyanite.
6. Mass of Tremolite with Kyanite Garnets and Prismatic Mica.
7. Quartz vein with Calcareous spar and pink Garnets.
8. Quartz vein with Garnets in ranges, and perhaps Epidote.
9. Vein of Tremolite with Brown spar.
10. Mass of Tremolite, Staurolite, and Pearl spar.
11. White Pearl spar including Bitter spar.
12. Flesh-red Pearl spar
13. Vein of striated Spathose Iron, with Crystals of Pearl spar.
14. Vein of purplish Quartz with Garnets.

The relations of succession and of magnitude presented by this section may be deemed to exhibit in the extreme, the prevailing principles of Geological Association. The space occupied by granite, with its subordinates, equals three-fifths of the whole, one-fifth of the remainder being allotted to gneiss and quartz rock, while argillaceous schist, upon the superior limit of the series, equals the two last in extension. The transition of granite to gneiss by the intervention of limestone, hornblende, and chlorite, and the apparently direct passage of quartz to argillaceous rock, are in the spirit of somewhat difficult graduation, but the methods of approximation and of transition, here less perfectly displayed, must appear under circumstances of the highest illustrative interest at the points of interference and collision of the series in its southward progress. In respect to economical suggestions which arise upon first regard, the extended plain of *Ellore*, the *Golconda* of proverb, yet remains intact, being but slightly encroached upon in the vicinage of a few hamlets, and if this tract may not again degrade the jewels of the earth, the speculation of glittering increase from it may be entertained. The groups of *Condapilly* and *Bezwarra* are stored with gems of the garnet tribe, and with varied mineral abundance, while the coast hills to the southward appear distributed in rich and nearly continuous successions of metallic deposits. And while nations of the western hemisphere assume a new genius through enterprise, awaked by their mineral advantages, the physical developement of these regions may conduce no less eminently to the interests of science and of wealth.

VII.

ON THE MIGRATION
OF THE
NATATORES AND GRALLATORES,
AS OBSERVED AT KATHMANDU.

By B. H. HODGSON, Esq.
ACTING RESIDENT AT KATHMANDU

The migration of birds is a subject which has, I believe, occupied and puzzled the observers of nature in all ages of the world, and which is still but very imperfectly understood. Were persons in various parts of the globe—particularly in such situations as are favorable for observation—to note down and make known the results of their individual experience, we might hope more speedily to arrive at the solution of the mystery, by collecting and comparing such scattered records. With this view, I beg leave to lay before the Society the general results of my observation of migrating birds, in the valley of *Nepal;* and, as the grallatorial and natatorial tribes would seem to be, at least in the East, the great and steady nomadic class of the feathered creation, I shall, in this paper, confine myself to them.

The valley of *Nepal* in shape resembles an oval or rather a diamond, being about sixteen miles in largest diameter either way; it is situated about half way between the plains of *India* and those of *Tibet*. The distribution of its seasons is essentially tropical; the valley is elevated above the sea about four thousand five hundred feet; and consequently the temperature averages from ten to fifteen degrees of Fahrenheit lower than that of *India* generally. The face of the valley is bare of wood and jungle, nearly every part of it being under cultivation, of which rice forms the principal object; and its population is dense and spread, at all times, for one industrious purpose or other, over almost every field in the country. The streams are numerous, but shallow: permanent swamps are small, but frequent. From the middle of November to the middle of February, little rain falls; the soil becomes gradually and slowly desiccated of its autumnal load of moisture; the cold is too severe for winter crops; and, hardly a blade of grass, or of corn, is then to be seen. From the middle of February to the middle of June, various sorts of mustard, pulse, field vegetables, and wheat, successively occupy a dry soil, which is daily growing drier; the accessions of fresh moisture from the spring showers being very moderate. From July to October the rains prevail, and rice covers the greatest part of the land; which is flooded, to promote its growth, in the earlier months: in the later months, as the successive crops ripen, the water is no longer artificially retained. The rains terminate usually with September: the first crops of rice are cut in the earlier fortnight of that month; and the last crops in the concluding half of October.

These general remarks upon the position, climate, and aspect of the valley will prevent the necessity of reiteration, by showing at once how far the country is fitted for the temporary abode of the birds alluded to: and, with reference to those birds which seek and frequent moist *woods*, it is only necessary to add, that the mountains confining the valley are covered every where with the noblest garniture of trees and copiously supplied with rills, and with mould saturated by these rills.

The wading and natatorial birds, generally, make a mere stage of the valley, on their way to and from the vast plains of *India* and *Tibet*, the valley being too small, dry, open, and populous for their taste—especially that of the larger ones. Some, however, stay with us for a longer or shorter time, in their vernal and autumnal migrations: and some, again, remain with us throughout that large portion of the year, in which the climate is congenial to their habits. Of all of them, the seasons of arrival, both from the north and from the south, are marked with precision; and I am led to conclude from what I have observed here, that the mass of the grallatores and swimmers are found in the plains of *India*, only during the cold months: for they all arrive in the valley of *Nepal*, from the north, towards and at the close of the rains; and all as regularly re-appear from the south, upon, or soon after the accession of the hot weather. In my enumeration of them, therefore, I shall divide the birds into the three classes, above indicated.

1st.—Of such as usually pass over the valley, seldom alighting, and only for a few hours.

2d.—Of such as alight and stay with us for a few days; or, at most, weeks.

3d.—Of such as seem to seek the valley—not as a caravansary merely, or house of call, for momentary or temporary sojourn in, on their way to some remoter abode—but, as their permanent dwelling place for the entire season.

A 4th class will be constituted of such as do not appear to migrate at all; notwithstanding that all their nearest kindred (so to speak,) do so regularly.

Class I. embraces—

Order NATATORES. Family *Anatidæ;* the Genera Cygnus and Anser: Family *Colymbidæ*, none; Family *Alcadæ*, none. Family *Pelecanidæ;* the Genera Phalacrocarax and Pelecanus. Family *Laridæ;* the Genera Sterna, Viralva, and Larus.

Order GRALLATORES. Family *Gruidæ;* the Genus Grus. Family *Ardeidæ;* the Genera Ardea, Phenicopterus, Platalea, Ciconia, Mycteria, Anastonus, Tantalus. Family *Scolopacidæ*, none. Family *Rallidæ* the Genus Glareota. Family *Charadriadæ;* the Genera Himantopus and Œdicnemus.

Class II. embraces—

Order NATATORES. Family *Anatidæ;* the following Genera, Tadonra, Anas, Hynchaspis, Dafila, Mareca, Querquedula, Merganser, Truligula. Family *Colymbidæ*, none. Family *Alcadæ*, none. Family *Pelecanidæ;* the Genera Phalacrocorax and Pelecanus.

Order GRALLATORES. Family *Gruidæ;* the Genus Anthropoides. Family *Ardeidæ*, the Genus Ibis. Family *Scolopacidæ;* the Genera Numerius, Limicula, Recurvirostra, Limosa, Rhynchœa, Pelinda, Phæopus. Family *Rallidæ;* the Genera Rallus, Parra, Gallinula, Porphyrio, Fulica. Family *Charadriadæ;* the Genera Erolia, Squatarola, Vanellus, Charadrius.

Class III. embraces—

Order NATATORES. Family *Anatidæ;* the Genera Mareca and Querquedula, (where *protected*, as in some sacred Tanks). Family *Colymbidæ*, none. Family *Alcadæ*, none. Family *Pelecanidæ*, none.

Order GRALLATORES. Family *Gruidæ*, none. Family ***Ardeidæ***, the Genera Botaurus, Ardœa, Ciconia, Family *Scolapacidæ*, the Genera Gallinago and Scolopax. Family Rallidæ; the Genera Parra, Rallus, and Fulica, (where protected, in holy Tanks). Family ***Charadriadæ;*** the Genus Charadrius, (one small species of.)

Class IV. embraces—

Order NATATORES, none.

Order GRALLATORES. Family *Gruidæ*, none. Family ***Ardeidæ;*** the Genera Ardea, (small species, or Baklas, only) and Nycticorax. Family *Scolopacidæ:* the Genera Totanus ? and Gallinago ? Family ***Rallidæ;*** the Genus Rallus. Family *Charadriadæ* -the Genus Vanellus, one species —the Tithirí.

N. B.—The notes of interrogation merely denote a doubt whether the Genera so indicated belong to Class III or IV.

REMARKS UPON THE ABOVE ENUMERATION.

The Grallatorial and Natatorial birds begin to arrive, from the *North*, towards the close of August, and continue arriving till the middle of September. The first to appear are the common snipe, and jack snipe, and Rhynchœa; next, the Scolopaceous waders (except the woodcock;) next, the great birds of the heron and stork, and crane families; then, the Natatores; and lastly, the woodcocks, which do not reach us till November. The time of the re-appearance of these birds, from the *South*, is the beginning of March; and they go on arriving, till the middle of May. The first which thus return to us are the snipes; then come the teal and ducks; then the large Natatores; and lastly, the great cranes and storks. It will be noticed that the Grallatores which visit us, or pass over us, are much more numerous than the Natatores ; and, unless I am mistaken, observation in the plains of India would satisfactorily prove that this is a just and decisive indication of the superior prevalence of wading over swimming birds in that extensive region. India, I fancy is too hot for the taste of the Natatores—a great majority of which seem to affect arctic regions, or, at least, high latitudes: I throw out the remark for canvass and enquiry : and, for fear I should deceive any one by the display of the Genus 'Cygnus' at the head of my list, I must add that the wild swan was never seen here but once, in the mid winter of 1828. when the apparition suggested a new version of the well known hexameter—

> 'Rara avis in terris, *alboque* simillima cygno.'

Such a bird is never seen, I suppose, in the plains of India?

None of the Natatores stay with us, beyond a week or two, in autumn (when the rice fields tempt them) or beyond a few days, in spring; *except* the teal, the widgeon, and the coot, which remain for the whole season, upon some few tanks whose sanctity precludes all molestation of them. There are cormorants throughout the season upon the larger rivers within the mountains ; but none ever halt in the valley, beyond a day or two for *so long*, however, both they and pelicans may be seen occasionally, on the tanks just mentioned.

Lest any one should admire my enumeration of Larus, and Sterna—birds which usually affect the high seas—I think it proper expressly to say that I have killed both the red-legged Gull, and a genuinely pelagic Tern, in the valley! But, so have I *fishing* Eagles ; and, in truth, who shall limit the wanderings of these long-winged birds of the Etherial expanse?

It will be observed, that I have not followed the arrangement of Cuvier, but that of Stevens, apud Shaw. The latter is adopted from our distinguished English Zoologist, Vigors; and as I think his distribution of Birds possesses many advantages, I have given it the preference to that of Cuvier, how much soever I may reverence the genius and knowledge of this distinguished Naturalist. Perhaps it may be objected to my enumeration that it ought to have descended to *species*; to which I answer that, besides the prolixity of such a catalogue, the avowed principle of the distribution of the feathered tribes which I have followed, is, to separate into a distinct genus, every bird or small group of birds which is distinguished by any marked peculiarity of organization or manners, whence it is probable, that my generical enumeration will suffice for every useful purpose.

NIPAL RESIDENCY,
5th October, 1831.

VIII.

THE WILD GOAT,

AND THE

WILD SHEEP, OF NEPAL.

By B. H. HODGSON, Esq.

ACTING RESIDENT AT KATHMANDU

I.—The Jháral Wild Goat, *Capra Jháral.* (Mihi.)

Habitat, juxta-Himalayan Mountains of Nepal.

SPECIFIC CHARACTER.

Goat with short, thick, simply recurved, sub-triangular, sub-compressed, carinated horns; sharp above, flat beneath; towards the tips, smooth and rounded: with beardless chin and double coat.

This capricious, vigorous, and agile, yet tractable and intelligent, animal, measures from the tip of the nose to the root of the tail, four and a half feet nearly; and stands two and a half feet high, at the shoulder.

His peculiar habitat is confined to the regions in the vicinity of the snows—but I am not aware that he ever ventures amongst the actual glaciers. He is capable of enduring, perfectly well, the heat of the valley of *Nepal;* and can be tamed and brought up in confinement, there, with the greatest facility. He possesses entirely the characteristic manners of the genus, so finely delineated by **Buffon**. Soon after his capture, (if he be taken young,) he becomes content and cheerful; and, within a year, he may be safely let out, to graze and herd with the tame sheep and goats. Intelligent and observant, he gives the keeper little trouble; and is an annoyance to the flock, only by reason of his wantonness: but, ever and anon, as it were in sheer contempt of sobriety, he will display the most amazing feats of activity, and the most fantastic freaks of humour. He is very wanton; and so ardently courts the tame females he may be turned amongst, that it is often necessary to deprive him of the tips of his horns, lest he gore them to death; or else to segregate and confine him. I have known him to have had sexual commerce with sheep, goats, and even musk deer; but never, to have begotten young by any of them. From the tame goat he is eminently distinguished by the superior compactness of his frame, length of his limbs, and expressiveness of his head; as well as by his fine deer-like ears and tail.

The body is shortish, full, and compact: the limbs, long but stout: the head moderate, with great vertical dimensions; small fine muzzle, and slightly convexed forehead, running in one uniform plane from the setting on of the horns to the termination of the nasal bones: neck, longish and slender, bowed out and down: ears, small and finely formed, erect, very moderately opened, having short hair outside, and naked almost, within: tail short, depressed; base broad, rapidly pointed: muzzle dry: no lachrymary sinuses. The *Jhóral*, in his ordinary quiescent attitude, has the back slightly arched; the withers lower than the croup: the hind quarters very slightly stooped: and the neck, in a small degree bowed, after the fashion of deer and antelopes. There is not a vestige of beard on his chin; the entire lower part of the head being as closely shorn as the upper surface. Upon the neck, especially the superior surface of it, —and upon the top of the shoulders, the hair is considerably elongated, and has, when the animal is in fine condition, a length of seven or eight inches. The rest of the coat is only of moderate length; and is full, fine, loosely applied to the body, straight, and mixed with a small portion of very fine wool at its base.

The long hair of the neck and shoulders is wavy, straight, and parted on the ridge, or apex of the body. The general colour is slaty gray, mixed with rusty on the flanks: forehead, and top of neck and back, red brown or dusky brown: fronts of the limbs, below the hocks and knees, the same: a line from the eve to the gape, and a lateral patch on the lower lip, the same: tips of tail and ears, black: base of tail, buttocks behind, and round the eyes, clear rusty: inferior surface of the head, impure yellowish; neck below, and centre of the belly, and insides of limbs, the same; but smeared with slaty: irides, brown red: muzzle, hoofs and horns, dusky black.

As it is by the horns chiefly that we are enabled to separate the species of this genus, I shall add a few more words upon them to the careful enumeration of diagnostics in the specific character. The *Jháral's* horns ascend very little above the crown of the forehead, being directed backwards with a strong convex curve which accurately describes a small segment of a circle; in as much as there is no peculiar twist towards the extremities of the horns. At the base they are in contact; and the separation of the tips is rather created by gradual attenuation than by divergency. Directly *above*, the horns present a sharp edge; which, towards their bases, is strongly carinated; but plain, forwards; and *below*, a broad surface, forming the third side of the triangle, the other two sides of which are the *lateral* surfaces of the horns.

of *Nepal*; and can be tamed and brought up in confinement, there, with the greatest facility. He possesses entirely the characteristic manners of the genus, so finely delineated by **Buffon**. Soon after his capture, (if he be taken young,) he becomes content and cheerful; and, within a year, he may be safely let out, to graze and herd with the tame sheep and goats. Intelligent and observant, he gives the keeper little trouble; and is an annoyance to the flock, only by reason of his wantonness: but, ever and anon, as it were in sheer contempt of sobriety, he will display the most amazing feats of activity, and the most fantastic freaks of humour. He is very wanton; and so ardently courts the tame females he may be turned amongst, that it is often necessary to deprive him of the tips of his horns, lest he gore them to death; or else to segregate and confine him. I have known him to have had sexual commerce with sheep, goats, and even musk deer; but never, to have begotten young by any of them. From the tame goat he is eminently distinguished by the superior compactness of his frame, length of his limbs, and expressiveness of his head; as well as by his fine deer-like ears and tail.

The body is shortish, full, and compact: the limbs, long but stout: the head moderate, with great vertical dimensions; small fine muzzle, and slightly convexed forehead, running in one uniform plane from the setting on of the horns to the termination of the nasal bones: neck, longish and slender, bowed out and down: ears, small and finely formed, erect, very moderately opened, having short hair outside, and naked almost, within: tail short, depressed; base broad, rapidly pointed: muzzle dry: no lachrymary sinuses. The *Jhóral*, in his ordinary quiescent attitude, has the back slightly arched; the withers lower than the croup: the hind quarters very slightly stooped: and the neck, in a small degree bowed, after the fashion of deer and antelopes. There is not a vestige of beard on his chin; the entire lower part of the head

To the above account of a wild Goat, proper to *Nepal*, I may as well add a short notice of wild Sheep of the same region; although I am acquainted only with the female of the species. This animal dwells north of the *Jhàral*, immediately beneath and amid the permanent snows, and is named, by the *Nipalese*, *Nayaur*, or *Nyaur*. It is distinguished by them (and, I fancy, justly) from the Ovis Ammon or Argali; which latter

---

Un examen sévère de leur nombreuse nomenclature, en indiquant la chèvre sauvage de Perse, (*capra agagrus*, Gmel.) comme la source de toutes les chevres domestiques, a également admis, pour espèces primitives, le Bouquetin du Caucase (*capra Caucasica*, Guldenst.) le Bouquetin de tout l' ancien continent (*capra ibex*, Lin.) et le Bouquetin à crinière d' Afrique (Daniels Afric scenery, 81. XXIV.) aux quels nous ajouterons la chèvre de Sumatra, (*cambing outang* de Marsden,) si distincte de toutes les autres par une grosse protubérance sphérique située au dessous des yeux

Avant d'être modifiés par la domesticité, les caractères génériques de ces animaux consistent principalement dans la disposition de leurs cornes dirigées en haut et en arrière, et dans la présence d'une barbe au dessous de la mâchoire inférieure. Quand aux caractères spécifiques, ils sont déterminés par la forme même des cornes, de sorte que l' on peut admettre comme espèce primitive et nouvelle, toute chèvre sauvage qui présentera, sous ce rapport, des différences constantes et notables.

Les espèces indiquées ci-dessus sont si bien connues, qu'il n'est pas besoin de rappeler leur description pour rendre sensible ce qui les distingue de la chèvre rapportée récemment du Napaul par M. WALLICH, nous bornant donc à décrire celle-ci avec exactitude, on saisira facilement les dissemblances qui la désignent comme une espèce nouvelle ou peu connue.

Sa taille est à peu près celle d' un bouc domestique, c'est-à dire qu'elle a environ 2 pieds 10 pouces à la partie la plus élevée du dos. Ses cornes sont cylindriques, annelées irrugulièrement à leur base, arquées dans toute leur longueur et dirigées en arrière vers le haut; les oreilles sont droites et la queue toujours basse, au dessous de l'angle interne des yeux est un vestige de larmier; le menton est privé de barbe et derriere chaque oreille se trouve une glande recouverte par la peau et qui secrète une matiere inodore s'écoulant par un petit trou percé au milieu.

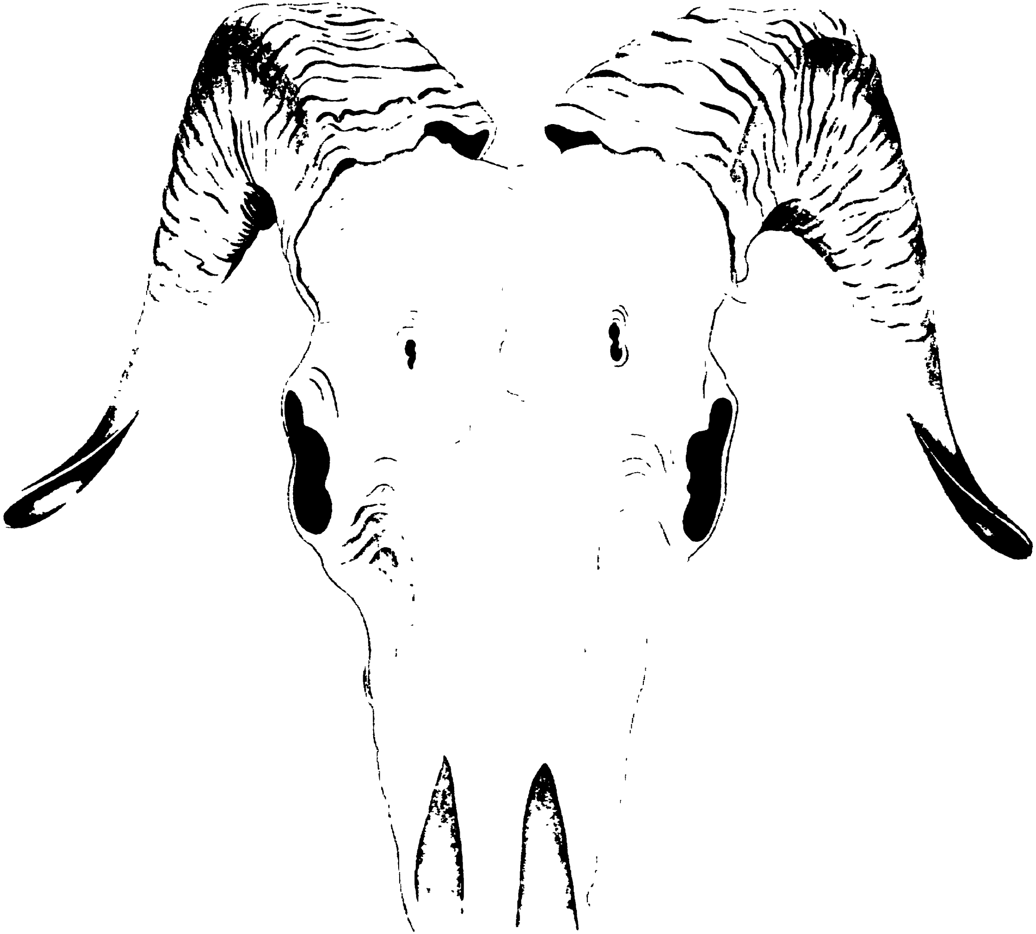
Le pelage de ce Bouquetin se compose de deux sortes de poils, ainsi que celui de toutes les chevres et de beaucoup d'autres animaux. Le plus long est pendant, rude et grossier, l'autre un peu frisé, soyeux et rare. Ce pélage est d'un gris varié de fauve et de noir; le fauve domine au ventre et sur les membres, le noir s'étend sur les parties supérieures et trace même une raie distincte de l'occiput à la queue. La gorge d'un beau blanc se dessine nettement sur le fauve du cou.

L'individu que nous décrivons est un mâle qui parait jeune encore. Son corps élance, ses mouvements brusques et ses jambes de derrière plus hautes que celles de devant sont les conditions d'une parfaite agilité commune à tous les animaux de ce genre. Il a éte rapporté des frontières du Napaul par M. WALLICH et se trouve egalement dans les montagnes de l'est limitrophes du Bengale."

they call *Bharal*. I have never been able to procure the *Bharal*, alive or stuffed: but I have obtained, occasionally, his horns, so justly celebrated for their prodigious size. Six years ago, I had a pair which I could only raise from the ground by a considerable effort. I mention this strong distinctive feature of Argali, because it is one that is familiar to the natives; who are thence unlikely to confound the species, so marked, with another. Unluckily, when I possessed the horns of the Bharal, I was too incurious about such things to make any note upon them, ere I gave them away: I am therefore unable to say whether the dry, stuffed, head of a male wild sheep which I now have, and which professes to be that of the *Nayaur*, be essentially different in character from the *Bharal* of the *Nipalese*, or, from LINNÈ'S Argali. LINNE'S specific character of Ovis Ammon is "*O. cornibus arcuatis, semi circularibus, subtus planiusculis.*" Now, the horns which I possess, and suppose to be those of the male *Nayaur*, are directly the reverse of this; for they present a sharp angle below, and a broad flat surface above; being in shape accurately triangular; with two sides of the triangle constituting the lateral surfaces of the horns, and the third side, their frontal or superior, surface. Beneath, there is merely the acute angle of the triangle. Besides, though the animal which bore the horns in question died ere he had quite completed his second year, his horns, large as they are, could never, I think, have reached, at maturity, the prodigious dimensions of those of the Argali. In other respects, these horns answer sufficiently well to the description of those of *O. Argali, apud* Shaw.—II. 379-80.

Subjoined is a sketch of the Horns under discussion, attached to the skull.

After these remarks upon the supposed male of the species, I now hasten to the account of the female.



Lieut Hodgson B H A del

HORNS and SKULL of the WILD SHEEP of the Himalaya.

male 20 months old - Ovis Nayaur or Argali

II.—The Nayaur Wild Sheep.—*Ovis Nayaur*. (Mihi.)

Habitat. The Himálaya.

SPECIFIC CHARACTER.

The male ? with large, accurately triangular, horns, flat above and cultrated beneath; curved and wrinkled as in the common ram :* a double coat: and beardless chin and neck. The female, with small, strongly depressed, sub-erect, sub-recurved, and divergent, horns, obsoletely wrinkled.

In proceeding from the description of an individual of the genus Capra to that of one belonging to the genus Ovis, it is scarcely possible not to pause and pay a tribute to the elegant genius of Buffon. Deficient, perhaps, in scientific precision, he yet studied nature with a truly philosophic spirit; and his pictures of the *manners* of animals are no less useful than delightful.

Nature having separated the sheep from the goat by no palpable *physical* signs, we consult Linne in vain for directions under which genus to place a newly discovered species of either; but, if we can procure living individuals of the species, and so observe their demeanour, we have but to turn to Buffon's lively and just contrast of the manners of the two genera, to be satisfied as to whether our animal be goat or sheep.

---

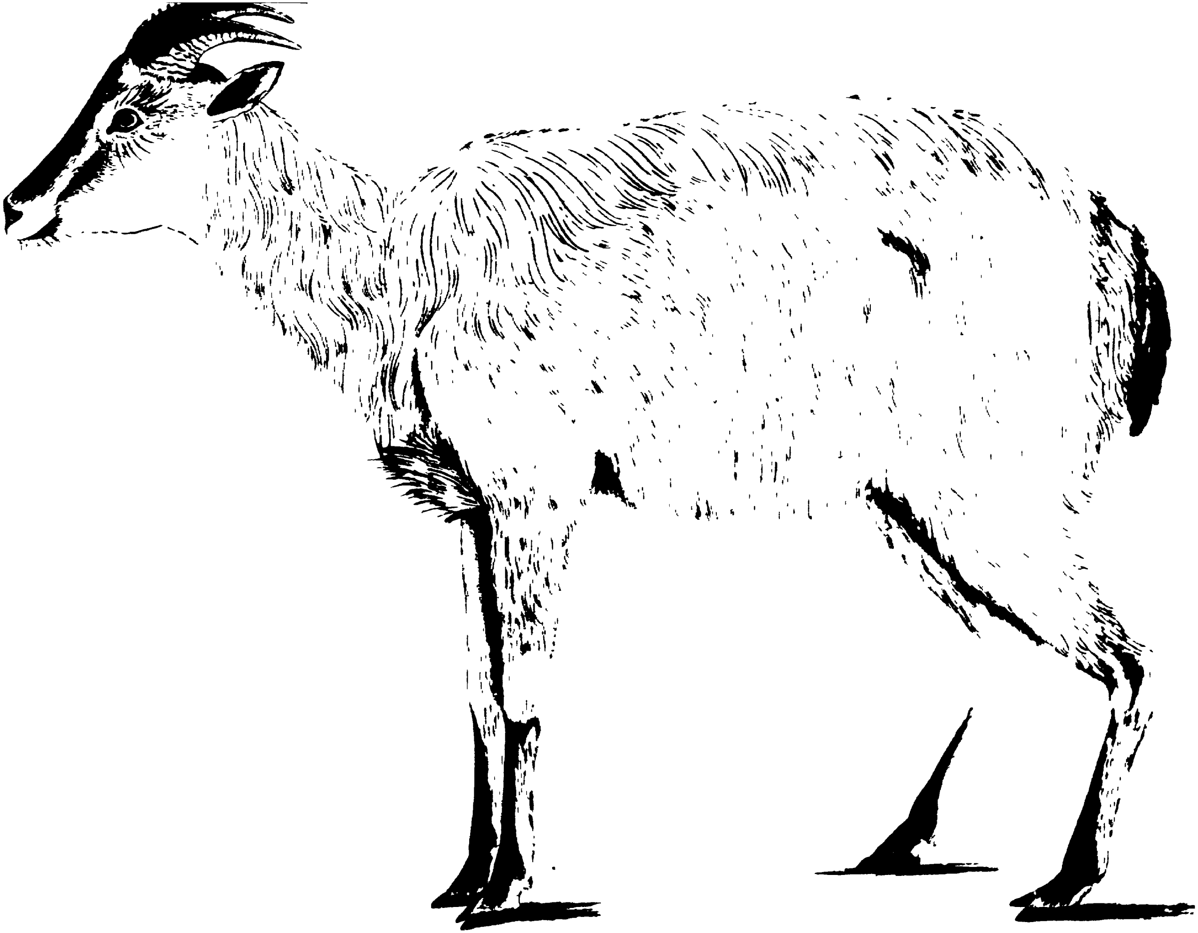
* Linnè's specific character of Argali gives horns, "arcuated, semicircular and flattish beneath"—that of *Ovis Aries*, "horns, compressed and lunated." Now, *Ovis Aries* is the common Ram: yet, Shaw says the horns of Argali are curved and shaped like those of the common Ram! I do not understand all this; but may as well add, ere I conclude this note, that my supposed male *Nayaur* has his horns curved, and formed generally like the common Ram's horns, from which they differ chiefly by being more accurately triangular. Are Argali's horns *trilateral ?*

Though I have kept and petted the *Jháral* and the *Nayaur* for years, I could never, with the dry Linnean aid of SHAW, have affirmed that the former was a goat, and the latter a sheep, but for the *moral* characteristics of the genera furnished me by the graphic BUFFON! I have mentioned that the *Jháral* is a saucy, confident, capricious, clambering animal, whose freaks of humour and of agility are equally surprising. The *Nayaur*, on the contrary, is a staid, simple, helpless thing, which never dreams of transgressing the sobriety of a sheep's nature. Like the *Jháral*, it is easily tamed, but requires more care to acclimatise it in the valley. I have tried in vain to breed from the *Nayaur*. Comparing the figure and general aspect of the two animals, it can merely be noted, in the way of distinction, that the *Jháral* is the more compactly framed, and stands straighter and firmer on his legs, than the *Nayaur;* and that the former has an arch genuinely goatish expression of the face—the latter, the proverbially simple look of the sheep.

As compared with the tame sheep, it is very obvious to remark that the *Nayaur* has a fuller, shorter body; much longer limbs; a longer neck; and ears and tail of a more deer-like character.

In the ordinary state of rest the *Nayaur*, instead of the straight back, neck, and limbs of the tame sheep, has the arched back, bowed neck and stooping hind quarters of the feet, and graceful antelopine and cervine races. There is a *great* drop from the shoulders; and the withers are lower than the croup: the head, as in the *Jháral*, but rather more rectilinearly tapered from above and below: ears, tail, and hoofs, likewise, as in the *Jháral ;* but the hoofs longer and less compact, and the ears larger.

The coat or covering of the *Nayaur*, as nearly as possible, resembles that of the *Chirú* or *Antelope Hodgsonii;* the most careful comparison only enabling one to say that the latter, from being somewhat thicker,



is more perfectly porrect from the skin; and that each of its hairs waved beneath the surface,* whereas the hair of the *Nayaur's* hide is straight—not merely in its general direction, but, in all its length, from point to point, of each hair.

Excepting such minute variations as these, all the ruminantia of the *Himálaya* and *Tibet*, which I have seen, are similarly clothed. There is always an outer coat and an inner: the latter, spare, very fine, woolly, more or less applied to the skin: the former, very thick, porrect, and of a substance which we must call hair, though it resembles not ordinary human or animal hair, or bristles. It is stiffish, brittle, feeble, rather thick or coarse, and of a quill-like feel and look. It might be imagined that this sort of hair is peculiarly adapted for protecting its wearers from cold: but dissection and the microscope fail to detect any peculiarity of structure.†

---

* It is not a twist, or, spiral convolution, but an alternation merely, on the sides, of salient and resilient curves.

† I speak under correction, and am favored by Dr. Bramley with the following observations: "It is most difficult to dissect a hair; but so far as I have performed the operation, the result confirms Mr. Hodgson's observation.

In regard to the waviness of the *Chiru's* hair, having examined a section of the fleece, and having found the alternations of salient and resilient curve looking into each other (that is, the salient bows of one hair fitting into the resilient bends of another) it struck me that this peculiar conformation might be of more importance than Mr. Hodgson seemed to imagine. I thought so when I examined the hair, and retain the opinion on reflection; as matter of conjecture merely, I would state, that the waviness of the *Chiru's* hair—which is more distinctly marked from the base upwards—may serve the specific purpose of confining the wool beneath in closer adaptation to the skin, under all changes of attitude by the animal, than if the hair were straight, and may thus constitute an additional security against injury from the rigour of that region which forms the *Chiru's* habitat."

J. M. Bramley.

The general and pervading colour of the *Nayaur* is a pale, dull, brownish, slaty-blue, which, however, merges into more superficial tints,—of rufous, on the flanks, hams, and shoulders; and of yellowish white, upon the cheeks, lips, abdominal surface of neck, belly, and insides of limbs, of ears, and of tail: bridge of nose, fronts of limbs, tips of ears and of tail, patch on chest, and line separating flanks and abdomen, dusky brown: in old animals, vertical line of neck and body, the same: iris, speckled, brown-red: muzzle, black: hoofs and horns, dusky.

Dimensions (of female) as follows:

	Ft.	*In.*
Tip of nose to roots of tail, ...	3	4
Length of the head, ...	0	9½
Ditto of tail to end of hair, ...	0	7
Height of animal, at the shoulder, ...	2	4½
Depth of the head, ...	0	6
Ditto of the chest, ...	1	0
Length of fore leg to line of belly, ...	1	5½
Ditto hind leg to ditto, ...	1	8½
Ditto of the horns, straight, ...	0	4
Basal breadth (across,)	0	1⅛
Ditto height, (fore and aft,)	0	0⅞
Ditto interval, ...	0	0⅞
Length of the ears, ...	0	5¾

Weight (of a very thin animal) 75 lbs.

N. B. The dimensions are taken from a female of less than four years old, three of which she had passed in confinement.

NEPAL, *October* 5, 1831.

IX.

ON THE

RATWA DEER OF NEPAL.

By B. H. HODGSON, Esq.

ACTING RESIDENT AT KATHMANDU.

III. The Ratwa Deer.—*Cervus Ratwa* (Mihi)

Cervus Muntjac ?—Pennant.

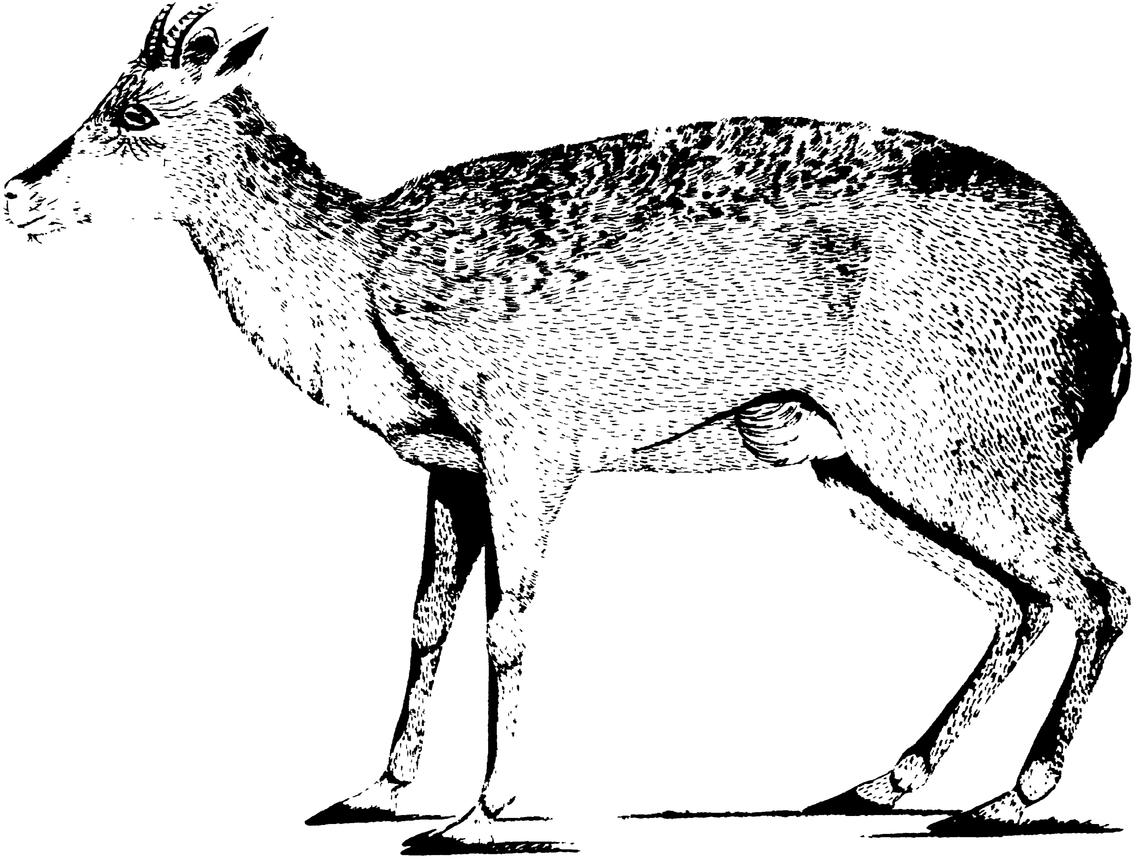
Habitat. Central and lower Hills of Nepal, and great Saul forest.

SPECIFIC CHARACTER.

Small red Deer, with very small, suberect, sublunated, bi or trifurcate, rounded, horns, set on lofty, hairy, compressed, pedestals; and with frontal as well as suborbital fissures.

This remarkable animal, whose horns bear some remote analogy to those of *Camelopardalis*, which is affined to *Moschus* by its tusks, and to *Capra* by its shortish and full body, as well as by its capricious and airy manners, has yet all the influential characters of *Cervus*, to which Genus it unquestionably belongs its muzzle being very moist, its suborbital sinuses extremely conspicuous, and its horns, annual, bony, and branched. But these horns, instead of being amply developed and springing immediately from the crown of the forehead, after the manner of most, if not of all, others, of the Cervine Genus, are so small as to deserve almost to be termed obsolete; and are elevated on pedestals higher than themselves, which pedestals are, nevertheless, covered to their summits by a continuation of the skin of the forehead. So that when the *Ratwa* periodically sheds his real horns, their pedestals, as above described, remaining, give the animal's head the very appearance of that of the *Giraffe*, so far at least, as the frontal prominences are concerned. Nor is this all: for, as much as these pedestals of the horns ascend above the crown of the forehead, so much do they descend below; their origin being the very extreme points of the *os frontis*, considerably below the insertion of the nasal bones. Here, then, the pedestals of the horns commence; and, in the shape of two prominent ridges, gradually diverging, they run along the outsides of the entire length of the forehead, only quitting the skull at the outer angles of the sutures connecting the frontal and parietal bones. Yet more: down the inner side of either of these ridges of the pedestals runs a most singular fissure, formed by a strong reflexion of the skin. The margins of the fissures are full and dilateable; and the animal expands them under excitement as well as applies them, so expanded, to objects of curiosity with the apparent purpose of feeling or smelling such objects; just as he applies the suborbital fissures. The frontal fissures are about two inches long, straight, and longitudinally directed down the sides of the *os frontis*. The skin is continued without interruption or sensible diminution of thickness throughout their interior: but the interior is nearly denuded of hair. When the hide is stripped from the carcase, there is no internal indication, not even the crease,—of the strong folds prevailing on the outside of the skin and forming the fissures: but there is a very slight indentation of skull corresponding with them.

The ridges of the pedestals are elevated nearly one-third of an inch, above the sides of the *os frontis*; and their substance is solid, and bony, like that of the skull, of which indeed the ridges form an integral part,



Rai Mán Sinch del.

The NYAUR or Wild Sheep of Nipal. *(Ovis Nayaur from Hemalayan.)*

Kasinath sculpsit

without the intervention of any suture. From the point where these ridges commence, to that at which they rise above the crown of the skull, their length is about four inches. From the latter point, the pedestals proceed, rectilinearly, but inclined rather backwards, about three and a half inches more; and there they terminate, and the horns commence. In this second portion, the pedestals are bony as before, and entirely covered, by a continuation of the frontal skin, with rather more than its usual quantity of hair on them. The pedestals have, in this their fully developed part, a strong lateral compression ; their shape being precisely that of an ordinary stick of sealing wax ; and uniform throughout. They have a gradual and not inconsiderable divergency amounting to about three inches at their summits. At the crown of the skull, their interval is about two inches. The horns which rise from these remarkable columns have all the well known characters of the genus. They fall off and are renewed, annually, between June and September ; their nucleus being a swollen marginal protuberance, just like the burr of the horns in common Deer. The horns are very insignificant, having an extreme length of about three and a quarter inches, and only a proportionate thickness. Like that of the pedestals, the general direction of the horns is upwards, with an inclination backwards. They are rounded, in the main, but have a slight lateral compression near to the pedestals : their surface, in general, smooth, but furrowed, more or less, by longitudinal grooves. The principal curve of the horns is an outward or lateral convexity, with the points turned, very decidedly, inwards ; and, less decidedly, backwards, but not absolutely "hooked"—at least not in the majority of individuals. Hence, in the specific character, I have called the horns sublunated. But the term can only be justly used in a quaified sense ; and, as not merely the points but the upper halves of the horns are, in some specimens, convexly turned *back*, though, in a less degree, than they are bowed laterally, perhaps they might be little less justly characterised as *subrecurved* than as *sublunated*. From the base of either horn proceed one or two erect, short, conical, branches—sometimes one from the one horn, and two, from the other of the same pair of horns. These branches (so to speak) are never above an inch long—where there is one only, it is thick—where two, they are slender. The second branch or antler is so rarely met with that it ought perhaps to be considered a lusus merely, and as such should be excluded from the specific character of this species : but, as I have one fine specimen in which two basal antlers are developed, and, as PENNANT expressly says his Muntjac is trifurcately horned, I think it safest to designate the *Ratwa* as bi-or-trifurcate, and not as positively bi-furcate only.

Having thus painfully, and I fear, tediously, described the pedestals, horns and frontal fissures, of the *Ratwa*, I shall now proceed to the account of its manners, haunts, appearance, size, and remaining characters.

This elegant and lively little animal bears a great resemblance in size, figure, and carriage to the Porcine Deer of the plains of India : but the *Ratwa* is the lighter and more graceful, considerably, of the two. His motions are full of elegance and elasticity, and he stands and even walks upon his toes rather than upon his entire hoofs, as though he disdained to touch the ground. In a quiescent state his back is much arched; his hind limbs stooped ; his withers lower than his croup ; his neck retracted, and bowed downwards and outwards ; his head carried low ; and his tail closely applied to his buttocks. Excite him ; and he will, at once, straighten his back, raise his fore quarters and head, erect his scut, and appear instinct throughout his frame with spirit and agility ! I have seen him, in pure display, as it were, separate his fore and hind legs extremely, and throw his back into a concavity as decided as ever is the convexity of the attitude of rest. The body of the *Ratwa* is, for a Deer, short and full : the limbs, too, short ; and stout as far as the hocks and knees--below them, exceedingly slight and fine : the hoofs, small and compressed : the false hoofs inconsiderable in size and blunt : the tail, longish, tapered, cylindrico-depressed, moderately and uniformly clothed with hair; in general resembling the tails of the Axis and Fallow Deer: the neck, shortish and rather spare: the head, rather large; of small vertical dimensions; tapered; the nose acuminated, and having a well defined, moist, and naked muzzle: the eyes large and beautiful, with transverse oblate pupils: the ears, rather small and well formed; moderately opened: the lining, a small quantity of longish, soft, hair, disposed into stripes or striæ on a naked ground; the tips, rounded. I have already observed that the muzzle is moist; and the suborbital sinuses, large and conspicuous. Comparing the cranium of the *Ratwa* with the skulls of other and large Deer, nothing markedly peculiar to the former arrests the attention save the two elevated ridges bounding the whole extent of the frontal bones, and which have been already particularly noticed. The cranium of the *Ratwa* may, however, be further distinguished by the relative length of the frontal, and correlative shortness of the nasal bones. The *Ratwa's* forehead is decidedly tho' slightly, convex; and the usual drop or depression is further forward, and less sudden than it is observed to be in large Deer. Owing to the character and position of their respective horns, the brain is thrown less far back; and, lastly, the nasal bones are void of that arcuation which usually belongs to those of large Deer. The bony cavities prepared for the lachrymal sacks, and corresponding with the suborbital fissures of the superficies, are, in the *Ratwa*, as large as, or larger even in proportion, than, those of the huge *Bára Sinha's* head. The tusks of the *Ratwa* have the same general character with those of the proper or *Tibetan Musk:* * but they are shorter, stouter, less compressed, and much more curved. The portion exerted from the jaw is about 1¼ inch in length,—measured straightly—2⅛ inches in extent as measured along the curve. They are loose in the sockets, but fixable at the animal's pleasure. The *Ratwa*, when taken young, can be tamed as easily and effectually as the spotted Axis: but it is volatile and capricious in its temper, reminding one a good deal of BUFFON's exquisite description of the Goat; only the *Ratwa* loves not rocks and precipices; nor possesses the Goat's wonderful power and propensity to climb and spring. The tamed *Ratwa* is a confident, fearless, creature, which, small as it is, will not retreat before man or dog, annoying it; but will (the male) turn on the assailant and attack resolutely both with its horns and tusks—cutting with the latter, in the manner of the wild Hog. The female of the species is gentle and timid, having neither horns or tusks; but, in place of the former, two bristly patches of dark hair like eyebrows—and of the latter, small conical canines not protruding from the mouth. She has four teats, disposed quadrangularly on a white udder; and a specimen procured on the 28th February, had the udder teeming with milk. This individual must have just dropped her young. She is rather smaller and paler in colours than the male. The *Ratwa* is about three feet five inches long, exclusive of the tail; about one foot eight inches in height, at the shoulder; and from forty to fifty lbs. in weight. Colour, a bright, uniform, full, yellow red;—darkest, above; palest, below, or on the belly and pectoral surface of the neck: forehead and limbs obscured with dusky-brown: insides of thighs, a patch on either side the chest, insides of ears and tail, pure white: a blotch of black in front of each pedestal of the horns, where the pedestals quit the forehead, on the inferior surface, and a good deal of the upper lip, impure white: irides, dark brown; muzzle and hoofs, black: coat or hair, close, full, soft, short, applied to the skin: in the living animal always exquisitely clean and void of all offensive odour.

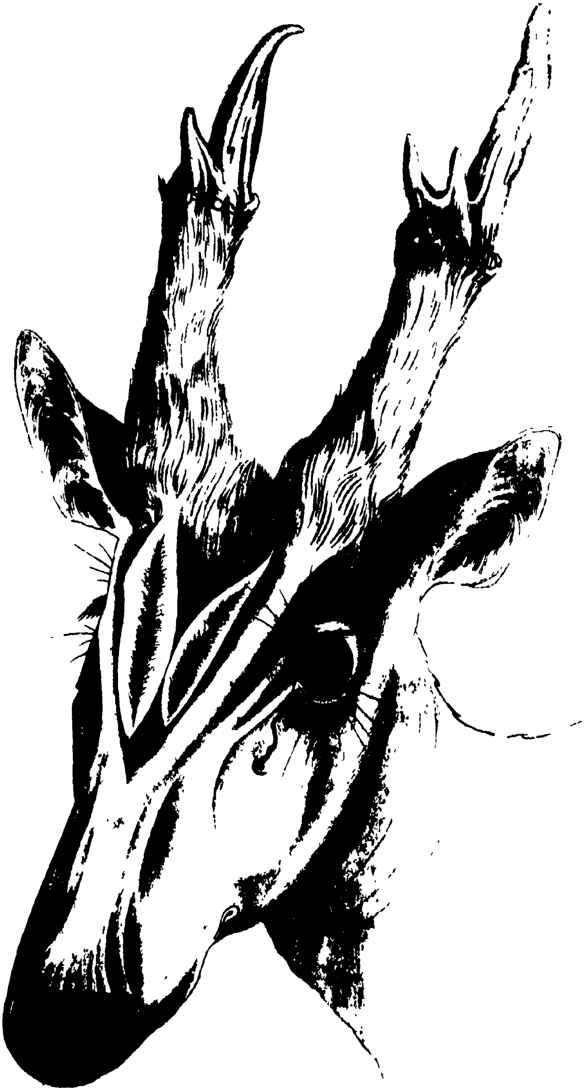
---

* Vide Shaw's General Zoology, vol II. p. 250.

The *Ratwa* is found in the great central mountains of *Nipal*, as well as in the small hills beneath them, and in the great forest at their foot. He is more common, however, in the latter than in the former tracts; and in the former he confines himself to the basal and gently sloping parts of the mountains; and, of them, to such districts only as are closely screened by brushwood, in the midst of which the *Ratwa* always has his lair. The species is gregarious—the herds usually amounting to from twenty to thirty individuals. The mountaineers denominate the animal, *Ratwa*. It is not known to the plains of India, I believe; nor to any other of the Indian mountains, as far as I am aware. Whoever will turn to SHAW's General Zoology, vol. II. p. 301, will find there the description of a small species of Deer denominated the Rib-faced Deer, or *Cervus Muntjac*, belonging to Java and the Malayan Peninsula; which I apprehend to be either a variety of the *Ratwa*, or another species most closely allied to ours. But SHAW's description is so wretchedly imperfect that it is impossible to speak with any confidence about it. I recommend the curious in such matters to read attentively my description and then to refer to SHAW's; by which means they will be able to appreciate the following remarks. The specific character of *Cervus Muntjac* gives "cylindric" pedestals to the horns, and makes the "upper fork" of the horns "hooked." Whoever had not seen the pedestals denuded of hair would take them to be cylindric, notwithstanding their really strong lateral compression: and, as the tips of the horns are—at least in some old males—strongly curved inwards and backwards, there is room to say that the "upper fork is hooked," though I cannot admire the mode of expression; because the insignificancy of the frontal fork or forks makes the expression "upper fork" as applied to the beam or trunk of the horns peculiarly apt to mislead. I have already intimated that the trifurcation of the horns is probably not a general or permanent characteristic. SHAW observes, that "that which chiefly distinguishes the *Cervus Muntjac* is the appearance of three longitudinal, subcutaneous ribs, extending from the horns to the eyes." The three ribs in question are, I suppose, the two frontal fissures, and their intervallary crease, which last, in the *dry skin*, presents almost as decided an indentation and apparent peculiarity of structure as the fissures on either side of it; owing chiefly to the constant habit the living animal has of dilating the fissures, whereby the skin of the forehead, contracted on either side by their dilatation, forms a strong crease between them. Nor, however strange it may at first sound to one who has beheld the living animal to hear that these "ribs" run from "horns to eyes,' is the thing at all difficult of solution by means of an ill-dried, distorted, skin. What is meant by the thickening of 'the pedestals at top, and their having the appearance of a rose *after* the horns are forced off, I cannot divine; unless, in the particular case, the horns should have been forced from the pedestals, leaving their own marginal protuberance or burr, attached to the pedestals. In one of BUFFON'S Supplements it seems the *Cervus Muntjac* is described as of a grayish-brown colour: if this be just, *Cervus Muntjac* will constitute, probably, a distinct species from *Ratwa;* and I cannot help thinking that, in such case, the two ought to be, sectionally at least, separated from Cervus. I have no late work on Mammalia to refer to, and must crave pardon therefore, if I have been anticipated in regard to that point; and perhaps also for the length of this paper; which yet should find its excuse in the acknowledged futility of summary descriptions of new and foreign animals. The following are the dimensions and size of a male *Ratwa*, which lately died in my possession.

	Ft.	*In.*
Tip of nose to root of tail,	3	4¼
Head, length of,	0	8½
Tail, ditto, to end of hair,	0	7¼
Height of animal, at shoulder,	1	7½
Utmost vertical measure of the head,	0	3¾
Depth of chest,	0	8¾
Length of fore leg, to elbow,	1	1¼
Ditto of hind ditto, to corresponding joint,	1	3½
Ditto of ears,	0	4½
Ditto of pedestals, above the skull,	0	4
Ditto of horns,	0	3½
Weight, 40 lbs...to 36 lbs.		

VALLEY OF NEPAL, *October*, 1831.



Head of the RATWA DEER of Nepal.

Cervus Ratwa, mas Hodgson

Raj Man Singh, Nipalensis de　　With frontal fissures dilated　　Gasnath sculpsit

NOTE

CONTAINING FURTHER INFORMATION RESPECTING THE OVIS NAYAUR.

Since the paper on the *Ovis Nayaur* was written, I have received a complete stuffed skin, but sadly distorted and injured, of a young male *Nayaur*. Though the animal when he died was not above eight months' old, he must have measured four feet in length from the nape to the insertion of the tail, and nearly three in height at the shoulder. He has a double coat exactly of the same character as, and rather thicker and longer than the *Chirú's*, whence it follows that the slight differences observed upon in the course of the paper were only the consequence of confinement, change of climate, and perhaps sex also, in respect to the *Nayaur*. From much conversation that I had with the *Bhotea* who brought me the skin of the young male *Nayaur*, I now incline to believe that I was mistaken in supposing there are two species of wild sheep in these regions. The *Bharal* of one dialect is probably the *Nayaur* of another; and the *Himalayan* wild sheep, most likely, only a variety of that widely diffused species, *Ovis Argali*, though I confess I cannot reconcile LINNÆUS' or SHAW'S descriptions of the horns of the *Nayaur*. The young *Nayaur* just received has the wool and greater part of the hair, beneath the surface, dull purplish gray slaty; merged in more superficial hues of rusty brown, above, and of impure hoary, below. The lips and inferior surface of the head, and insides of the shoulders and thighs, pure white: superior surface of the head, like the body above, but paler. no dark marks on the limbs, flanks or forehead, as in the female: neither this young male nor the female before described, have any appearance of that peculiar elongation of the hair upon the pectoral surface of the neck for which *O. Argali* is conspicuous.—But the circumstance is no way decisive, owing to the youth of the one and the feminine gender of the other—such appendages most usually appertaining exclusively to mature males. As the young *Nayaur* now spoken of was taken in midwinter and died immediately, his coat must exhibit the full winter raiment of the species. The hair is about two inches long, and so thickly set on as to stand erect from the skin, in its ascent from which the hair is accompanied about half way by a spare-fleece of fine wool. A larger quantity of the same material lies closely applied to the skin: but the whole quantity of the wool is much less than that of the hair. The horns, though small, have exactly the form already described and figured, and justly referred to the male *Nayaur*, as I have now satisfactorily ascertained.

IX

SHORT SKETCH

OF THE

GEOLOGY OF PULO PINANG

AND THE NEIGHBOURING ISLANDS,

WITH A MAP AND SECTIONS.

By T. WARD, Esq.

ASSISTANT SURGEON MADRAS ESTABLISHMENT.

The geographical situation, the extent and general appearance of Prince of Wales' Island are well known, and it will not be necessary to dwell upon them here, more especially as they are included in the accompanying Map.

Pinang may be described as being formed of a group of hills occupying about two-thirds of its extent, running through its centre from north to south, and having a plain on its eastern and western sides. The hills, thickly covered with lofty forest on all sides, seem at first sight so irregularly grouped, as to defy all arrangement; but on more accurate examination, they may be divided into three principal chains, commencing at the north, gradually approaching towards the south, where they form one narrow barrier between the two sides of the island, branching off at last, along its southern extremity, at right angles, east and west. The middle chain, including the western hill and Mount Elvira, is that of greatest elevation, being about two thousand five hundred feet above the level of the sea. They are all loftiest towards the north, decreasing gradually as they advance southward. Between the terminations of the chains towards the north are deep bays and sloping vallies, filled with alluvial deposit. The greatest diameter of each hill is from north to south. The general outline is rather blunt and ridged, presenting no very bold peaks or points. Some of the lower hills are obtusely conical. Besides the principal group above described, there runs a small chain parallel to the east coast of the island, behind the Nutmeg Plantations at *Glugor*, of an elevation varying from six hundred to eight hundred feet, uniting with the great range near its southern extremity. There are also some isolated hills along the coast, the principal of which are Mount Erskine, Mount Olivia, and Mount Albina.

The valleys are not deep; few of them have very abrupt, and none, precipitous sides. The whole group, or rather series of chains, is so closely covered with forest, that not a bare spot is visible, except where the industry of man has been exerted. The height is not sufficiently great to produce much effect upon the nature of the vegetation; but small as it comparatively is, towards the summits, the palms and ferns increase in number, and the forest in general becomes more stunted, though even on the highest point are to be seen some magnificent timber trees. An arborescent fern of great beauty, rising to the height of from fifteen to twenty feet, is met with only on the great hill at a considerable elevation.

The soil of the hills is a reddish light sandy clay from the decomposition of the granite composing them, the process of which may be seen going on, wherever roads have been cut below the surface. It is seldom more than eight feet in depth, most frequently less, and the vegetable mould above it is from six to twelve inches. There is little gravel and no fragments, except occasionally of quartz, probably from exposed veins.

The whole of the group of hills, and indeed every rocky or elevated part of Pinang, is composed of granite. No other mountain rock occurs in immediate connection with it. It varies in grain, in colour, and occasionally in the proportion of its ingredients. It is every where traversed by veins of quartz and quartz-rock, which are often of large size. Commencing at Fort Cornwallis, and going round the island, first to the north, we find the following varieties: at *Pulo Ticoose* Point, where the beach is rocky, and composed of immense fragments, it is of a fine grain and grey colour, as in specimen No. 54. At *Batu Feringí*, where a small stream forms a magnificent waterfall, and a great mass of rock is exposed, the granite of rather coarse grain (No. 1*) is traversed by a vein of quartz rock (No. 2) resembling primitive sandstone, very hard, and from two feet to two and a half feet in breadth. In it, the stream has formed numerous tub-like cells, some of them two or three feet deep. I have seen some fine specimens of colorless rock crystal, containing crystals of schorl, which were collected here, but I had not the good fortune to meet with any on my visits. At the east point of *Tuloh Bohang*, the granite is grey and coarse grained (No. 3). At the west point of it, it is of a fine grain and of a slightly greenish colour. On the beach, to the west of *Kúcha Múka*, a small village on the north side of the island, among the rolled masses of granite are some with beautiful veins and imbedded crystals of quartz, and prismatic crystals and amorphous portions of hornblende? (No. 5). Specimens of these, of good size, were, with difficulty, broken off; and indeed to shew them in perfection, it would be requisite to carry away the rolled masses entire. No. 6, is a specimen of the granite found opposite Saddle Island, of moderately fine grain, and containing a large proportion of mica. On the south-west the granite, containing a large proportion of felspar and quartz, is nearly of a whitish colour—(No. 16). At night, from reflecting the moon's rays, it is observed to glisten at the distance of more than a mile. Imbedded in it, we found a globule of fine grained black granite, containing abundance of mica (No. 17). The whole of the south side of the Island is composed of a coarse brownish granite (No. 18). On the south-east point opposite *Pulo Rimau*, it occurs again of a grey colour (No. 19). These different varieties found along the coast, occur also in the body of the mountains, and it has therefore been considered unnecessary to transmit specimens taken from the interior.

---

* The figures throughout refer to the numbers of the specimens herewith sent.

* The east and south-west plains are entirely of alluvial formation, probably in great measure formed by the detritus of the mountains washed down and collected through the lapse of ages. At first sight of the east plain particularly, which juts in a triangular form into the narrow strait between the Island, and the Quedah coast, and on which are built George Town, the Fort, the various public buildings and the habitations of the English residents, the geologist is impressed with the idea that the sea must have at one time covered it and washed the base of the mountains. This is confirmed in some measure by the phenomena observable on the opposite shore of Quedah, where Captain Low has traced the successive deposits of

---

* Some of the following remarks on the plains, rivulets, water, &c. have already appeared in my "Contributions to the Medical Topography of Prince of Wales' Island," printed by the Pinang Government.

alluvial matter, for several miles inland, and the gradual retirement of the ocean indicate by ridges running parallel to the present line of coast. The process of conversion of such a hard material as granite into alluvial matter is distinctly seen on the road to the Great Hill, in the small valley between "Mount Olivia" and the "Highlands of Scotland." The precipitous bank, about sixty or seventy feet in height, presents a mass of red clayey sand, used generally in lieu of gravel for repairing the roads, which is merely decomposed granite as seen in the specimens Nos. 55 and 56, taken from the spot. Notwithstanding this alluvial origin, no organic remains, not even shells, have been found hitherto imbedded in any part of the valley. Query—may not this be accounted for, by the small number of animals which inhabit the island, and by the paucity of shells now in existence along the coast? The indigenous animals are principally birds and insects, and on two tours round the island, I did not discover in all one hundred shells on any part of it.

The soil of the valley is various. Near the point it is sandy, with a surface of about four inches of vegetable mould from decayed leaves and branches of trees. In advancing about a mile into the interior, the ground begins to rise, and the superficial stratum is also a light vegetable mould, about a foot in thickness, resting on the sand. Near the foot of the mountains, the soil becomes rich in many places, and beds of white clay resembling fuller's earth, are found here and there, more especially in *Pulo Ticoose* bay In those parts of the island, near the sea coast, which are generally overflowed and thickly covered with mangrove, *(Rhizophora)* the soil for a foot in thickness is a rich black mould. Throughout the island it is light, and in most parts is composed of clay, with a large portion of sand, which renders it very porous.

Water, generally speaking of good quality, is to be had in almost every part of the island by digging a few feet below the surface. In some places it is slightly brackish; in others it is tainted by passing over the decayed roots or leaves or branches of trees; and sometimes it is mixed with the clayey particles of the soil over which it runs. There is no large river in the island; the several rills from the mountains collect into two or three rivulets, which traverse the valley in different directions. Their beds are sandy; the water pure as crystal, and of excellent quality, unimpregnated with any deleterious ingredient. I am not aware of the existence of any mineral water in the island

Stream tin has been found near Amee's mills, at the east foot of the great hill, and at *Batu Feringhee* on the north side of the island washed down from the containing veins which have not yet been discovered. Indeed the immense mass of vegetation, which so closely covers the island, that scarcely an exposed portion of rock can be found, renders it extremely difficult to trace them. At both of the above mentioned places the tin was collected for some time, but the works were given up as the quantity was not sufficient to cover their expence.

Round the island are extensive mud banks, which, on the north and east sides especially, are left uncovered at low water On the north-east side of the tongue of land, forming the valley, from *Pulo Ticoose* point to Fort Cornwallis, extensive changes have taken place within the last twenty years Between the outworks of the Fort and the beach there was formerly a space of about one hundred yards occupied by a row of cocoanuts, and a walk along the beach. Now the sea washes the very walls, which are in part destroyed by its encroachments. The houses on the beach also for some distance, are endangered by the same circumstance; the banks have been rapidly diminishing, and the strongest bulwarks of stakes and stones are necessary for their protection. In *Pulo Ticoose* bay, on the contrary, the sea has been retiring, the mud bank is daily increasing, and the mangrove has been gradually extending itself. It is too likely that some years hence, the bay may be entirely filled up. These changes are probably owing to the tides setting in strongly from the northward and westward. *Pulo Ticoose* point protects the bay from their action, which is exerted in full force upon the Fort point, or *Tanjong*, as it is called by the natives.

The sand along the coast, round the island, is generally whitish and pure: in some places, however, more particularly on the north side, it is nearly black, from the intermixture of numerous small particles of mica.

So much for *Pinang* itself. We now proceed to the neighbouring islands, commencing with those to the northward.

I. *Pulo Ticoose*, or Rat Island, is merely a barren rock of white granite, with a few large canes. It is about a mile from the north east point of *Pinang*, is of small extent, and offers no geological phenomena of any interest.

II. The *Boontings* are four small islands to the north of *Pinang*, arranged in a semi-circular form, the nearest being about fourteen miles, the farthest about twenty-five from Fort Cornwallis. The most remote one, from a fanciful resemblance to a "*femme enceinte*" lying on her back, has received from the natives the name of *Boonting*, a Malay word signifying "pregnant." In connection with this idea, the other islets have derived their appellations. That nearest Pinang is called *Beedan*, or "the midwife"; the name of the next is *Panghul*, or the messenger sent to call her,—and behind it is *Sonsong*, or the companion of the messenger.

1.—***Pulo Beedan***, or ***Bidan***, is about a mile in length and three-fourths of a mile in breath, of an elliptical shape, with a bay on its southern side. It is thickly wooded, the trees, as usual, coming in most places down to the water's edge. It may be noticed here once for all, that this circumstance offers an obstacle to the complete investigation of the geological structure of the island round *Pinang*, as it does of *Pinang* itself in some measure. The interior cannot be penetrated, and were it even possible to do so, the closeness of vegetation would shut out all view of the rocks. The observations are thus necessarily limited in most instances to the coast. The beach, on *Pulo Bidan*, near the south-east point, is composed of an argillaceous rock, resembling grey wacké, both lamellar and conglomerate, irregularly intermixed, (Nos. 41 and 42). This seems to dip at a considerable angle to the west; it is entirely covered at high water by the sea, and the outgoings or crop of the strata form sharp ridges, more or less elevated. Rolled masses of ironstone, (No. 43,) are found on it, of various sizes. On the argillaceous rock, rests a mass of limestone stratified, the strata dipping to the south-west at an angle of 45° It is of a bluish grey colour, (No. 40,) and at first sight seems to have a slaty texture. The colour of some of the strata is nearly black. They are every where traversed by veins of quartz and calcareous spar, irregularly intermingled. The whole island seems to be composed of the same material.

2.—***Pulo Panghil*** is a small rather elevated island, about two miles to the northward of the preceding, and celebrated for its turtles, which lay their eggs in the sandy points and bays. The coast is covered with smooth round stones of argillaceous matter, probably rolled over from *Pulo Sonsong*; but the body of the island is composed of the same kind of limestone as *Pulo Bidan*, (No. 45). In Turtle-bay, at the distance of ten or twelve yards from the main body of the island, some isolated strata of grey marble,* (No. 44,) of fine grain, and highly crystallized, dip at an angle of little less than 45° to the westward.

3.—*Pulo Sonsong* is about three miles to the northward of *Pulo Panghil;* a mile and a half in length, and about one broad at its southern extremity. At the landing place, a small sandy point, we observed some masses of coral rock, close to the beach, and the whole coast was covered with broken pieces of white coral thrown up by the waves The island is rocky and bold all round, and as usual thickly covered with wood. The rock (Nos. 46 and 47,) is entirely argillaceous, running in regular strata, at an angle of more than 65°, and dipping to the eastward. On the beach it presents more of the schistose or lamellar structure, (No. 46,) and is every where traversed by veins of quartz, (No. 49,) with a coating of a black substance, (metallic?) On the south and east sides, and apparently forming the lower strata of the island, the rock is of a reddish color and soft, (No. 47). On the west side, which is particularly bold and precipitous, it is of a bluish grey colour, soft and silky in same places, presenting the slaty texture, (No. 48,) but not splitting into thin lamellæ as regular clay-slate does. On this side are numerous caves; and the precipices crowned with lofty trees, the immense fragments of rock, the dashing of the waves against them, and the hollow sound of the water rushing into the caverns, have all an imposing effect on the observer.

4.—*Pulo Boonting*, about four miles north of *Pulo Sonsong*, is of nearly oval shape, thickly covered with wood, about one and a half mile long, and one in breadth at its broadest part. It is precipitous only on its north-west side; in all other places, the forest comes close down to the shore. There is the channel of a mountain torrent on the north side, choked up with large fragments of rock, at the foot of which is a spring of excellent water. The rocks are entirely granitic, the feldspar of the granite being in a state of decomposition, (No. 50). Large veins of quartz, in some places highly crystallized, traverse them in all directions, (No. 51). Among the rolled masses of the channel above mentioned, are specimens of a greener granite, approaching to primitive greenstone, (No. 52); and on the beach were found a few pieces of black limestone, (No. 53,) probably conveyed from *Pulo Beedan* or *Sonsong*.

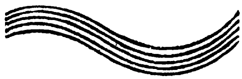
---

* This is well adapted for architectural purposes: and is fully equal to that brought from *China* at considerable expence.—I am now aware that its existence in the neighbourhood was known heretofore.

Round the whole of the *Boontings* the sea is beautifully clear; and the coral beds are distinctly visible at a considerable distance below the surface of the water. The only one inhabited is *Pulo Bidan*, in which live, in huts of miserable construction, about twenty Malays, engaged in catching and drying fish for the *Pinang* market. In sailing round these islands, we had a magnificent view of *Quedah* peak, or *Gunong gerai*, on the mainland, which rises to the supposed height of five thousand feet. Its composition, I am informed, is entirely granitic; its outlines are bold, sharp and pointed; the sides are steep, rising rapidly from the base; and it presents one immense dense mass of vegetation, unbroken some here and there by a few precipitous white crags. By the aid of the glass, we discovered the channel of a mountain torrent, which, in the rainy season, must form splendid cascades in its course. It has never been ascended by Europeans, and so great is the jealousy of the *Siamese* government, in whose territories it is, that it is not likely it ever will be. The whole of the coast below it, seems one flat uncultivated plain, covered with mangrove, extending a considerable way inland

III. *Pigeon Island*, situated near the southern extremity of the west side of *Pulo Pinang*, is of small size, and thickly covered with jungle. The rocks at the base, from the action of water, present some most fantastic forms; now, like a huge wall standing apart from the rest, now, like a Martello tower; and sometimes like a piece of Hindu sculpture from *Mahabalipuram* or the caves of *Elora*. It is entirely composed of coarse grey granite, with a large proportion of mica, (No. 6.)

IV. *Saddle Island*, or *Pulo Kundit*, about two miles distant from the south-west point of *Pinang*, is about two miles in circumference, being three-fourths of a mile long and one-fourth broad. Like all the other islets we visited, it is thickly covered with jungle and a few forest trees. On its north side these approach within a few feet of the water. The south and west sides are bold and rocky, the rock in some places being nearly perpendicular, and on the west side there is a deep bay, where several prows might lurk in safety. All round are numerous caves and cave-like fissures, into which the sea rushes with a hollow sound. The constant action of the water has so much worn the rocks, close to the edge, that they present at first sight the appearance of lava. At low water mark a great quantity of coarse coral is to be found, which is collected and removed by the lime-burners, in lieu of limestone. The geological structure of the island resembles that of *Pulo Sonsong*, formerly described. It is a mass of argillaceous schist of various colours, according to the greater or less action of the weather, but principally grey, bluish, and red, amorphous in many places, but presenting a laminar, and even fissile slaty texture in some, especially on the east side. It is distinctly stratified throughout; the strata running north-west and south-east, at an angle of about sixty degrees. Near the beach on the east side, the out-croppings of the strata, as on *Pulo Sonsong*, form sharp ridges; the rock is soft and of a reddish colour, (No. 8,) traversed by veins of quartz, and of a metallic matter (?) In some places the veins appear to be of quartz, mica, and chlorite blended together, (No. 9). The body of the rock on this side, above the red material, is an amorphous grey-wacke looking substance, resembling old sand-stone, (No. 7). Above this again is the more slaty-looking rock, (No. 12,) resembling clay-slate. On the south-east side, it seems entirely composed of the red argillaceous rock above mentioned, (Nos. 10. and 11). On the south-west and west sides of the island, from the precipitous nature of the coast, the structure is easily noticed. The rock is entirely like clay slate, (No. 12,) presenting more or less of the laminar structure, slaty in some places, as marked in No. 15. In some parts there is a bending in the strata, similar to that sometimes observed in gneiss; thus



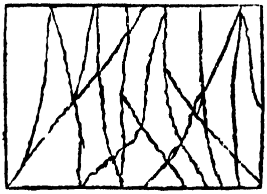
The rock is traversed by veins of quartz of about three inches in breadth, (No. 13,) and of a substance like iron-stone, (No. 14,) which also runs in thin laminar beds through the slate. In the rolled masses, near the beach on the east side, are observed portions of indurated clay, tinged with chlorite.

V. *Pulo Rimau* is situated at the south-east corner of *Pinang*, from which it is distant about three-quarters of a mile. It is of an oblong shape, about a mile in length, and one-third of a mile in breadth ; bold and rocky except on the north side; covered as usual with wood, and composed entirely of grey granite of a fine grain, (No. 20). On the south side, the rocks are rather fantastically shaped. One at a distance exactly resembles the gable of a house. They were all exceedingly hard ; and with a good sized hammer, I could with difficulty break off specimens of proper size. Near the centre of the south side of the island, a curious appearance presents itself. Veins of from one and a half to two feet in breadth, of quartz rock (Nos. 22 and 23,) traverse the granite in different directions. The walls of the veins are of a red colour, and finely crystallized, (No 24).

The granite is more compact and finer grained, as if compressed by the quartz rock, while in a semifluid state. Veins of red granite, and bed-like masses of it are observed in the neighbourhood, (No. 21). In the old stockade on the north side, we saw a rolled mass of primitive greenstone, (No. 25.), probably part of the ballast of some vessel, as none like it is to be found *in situ*, near *Pinang*.

VI. *Pulo Jerajah* is the largest and loftiest of the islands round *Pinang*, from the east coast of which it is distant about three-quarters of a mile. It is about two and a half miles in length, and nearly a mile in breadth at its broadest part. Its greatest height is at its north end, where the hill is between three hundred and four hundred feet above the level of the sea. It is entirely composed of fine grey granite, with a small proportion of mica, and is of no interest in a geological point of view. The soil is a fine red clay, and the trees grow to a great height, with remarkably luxuriant foliage.

VII. *Pulo Kra*. Two islands close to the main land of the *Malayan* peninsula, near *Batta Kawang*, are so named: they are separated from each other by a narrow channel: each is about a mile long, and about four hundred yards in breadth, rather lofty and thickly covered with wood. Their geological structure resembles that of Saddle island, above described, distant from them fully thirteen miles, with *Pulo Rimau*, of granite formation, between them. The principal rock of the northernmost, *Pulo Kra*, is a kind of argillaceous schist, which is of a laminar structure, and disposed in strata dipping at an angle of about forty-five degrees to the south-east; traversed by veins of quartz, with a crust apparently of metallic matter running down in long black perpendicular lines along the face of the rock, occasionally crossing each other in a net-work fashion; thus—



It is of various colours and consistence, probably as it has been more or less subjected to the action of the weather. It is sometimes greyish white, (Nos. 27, 28, and 31.) sometimes reddish, (No. 30.) sometimes blue, more or less deep, Nos. 26 and 29). Every where it presents the laminar structure, and splits into tables when struck with the hammer. The veins vary from half an inch to one and a half inch in thickness, and the quartz in them seems to be broken in pieces, between which is observed a metallic(?) crust, (Nos. 32 and 33). The beach is stony and clayey, different from that of the granite island, which we invariably found either rocky, sandy or gravelly. At low water mark, the quartz veins form a curious cancellated appearance. The softer rock between them having been destroyed by the action of the water, they rise in sharp lines considerably above the level of the clay, and are, in some places, scarcely passable without danger of having the feet cut or bruised. Beds and rolled masses of iron-stone were seen along the coast, near the north-west corner more especially; the former dipping at an angle of about 52°. The rolled masses are of considerable size, some being twelve or fourteen feet high, and as many in breadth, locking, at first sight, like volcanic rocks, from their burnt and cancellated appearance. They are formed of a kind of jaspery iron-ore, containing numerous drusy cavities, coated with semi-globular crusts of chalcedony and yellow ochre, some of the specimens of which are very beautiful, (No. 34). The specific gravity of it is 3.000. It strongly resembles, in all its characters, the mineral substance described and figured by Mr. Sowerby, in the 5th volume of his British Mineralogy, page 173. tab. 494, under the name of "Burnt rock. No. 35 represents another ore of iron, of specific gravity 3.640, found also in rolled masses on the coast, from which that valuable metal might be obtained in abundance. In some places, by the action of the water, the softer iron-stone has been converted into a fine yellow ochre, which might be used in painting. The whole of the west side of north *Pulo Kra* is rather bold and rocky, in some places even precipitous; and here and there are deep caves. Along the shore are round numerous sea slugs, or *Holothuriæ*, and the beautifully polished and variegated *Cypræa* shell, besides coral and sponges of various kinds.

Near the centre of this side, about one hundred yards from the shore, is a small detached rock, resembling, at a distance, the ruins of an Indian Pagoda, entirely composed of a soft red clay, impegnated with iron, (No. 37,) similar to what is called *Gerú* by the natives of India, and which, like it, might be used as a coarse paint. The lowest stratum of the southernmost *Pulo Kra*, is a very hard compound rock, which, for want of a better appellation, I have called grey wacke, composed seemingly of quartz and felspar, very compact and of a blackish blue colour, traversed by numerous veins of quartz, large and small, in every direction, (No. 38). The upper rock is the same argillaceous schist as that composing the northernmost. This structure is well seen at the south-west point of the Island.

Batta Kawang, on the main-land less than a mile cross from *Pulo Kra*, is composed entirely of granite. It is a hill about two hundred and fifty or three hundred feet high. Behind it are extensive sugar plantations. The soil is a fine rich clay mixed with sand. On the east side of the hill, beds of potter's clay occur, from which the coarse conical pots, used in the manufacture of sugar, are made. The small hills along the coast of the main-land opposite *Pinang*, are, I understand, entirely composed of granite. On this subject, however, I shall not enlarge, as Captain Low has already published an account of their structure in the First Volume of the Transactions of the Physical Class. For the most part the ground is alluvial, and, as stated by Mr. Finlayson, in his account of the Mission to *Siam*, in some places, resembles peat-moss.

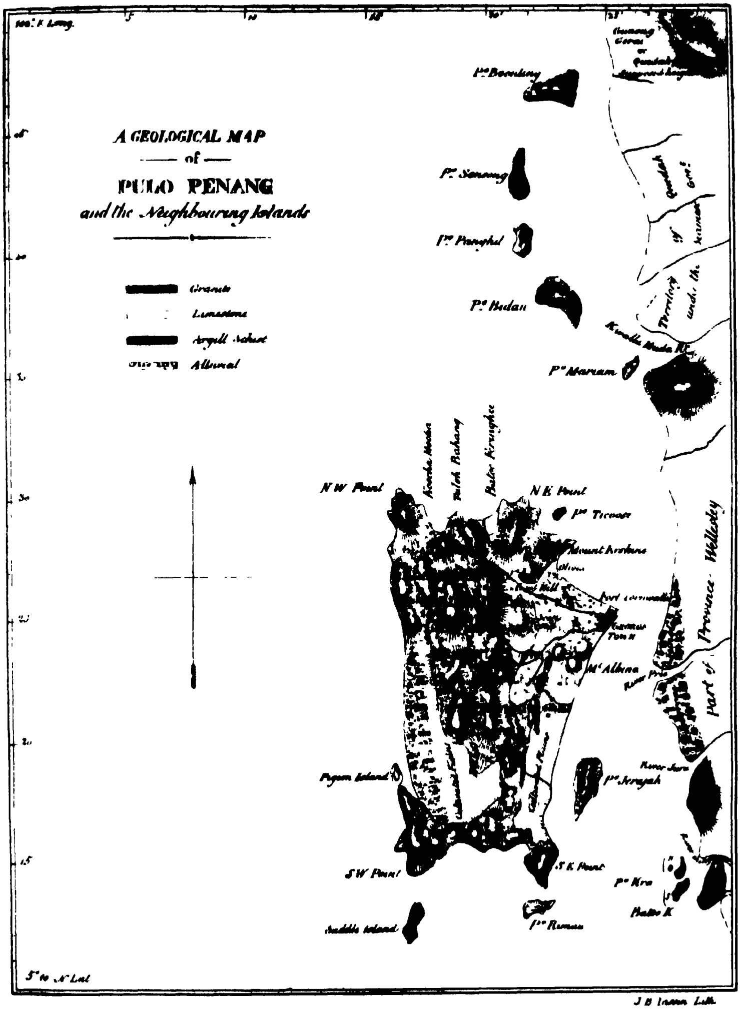
Such were the observations which I made on two tours round this Island, in which every part described was carefully and minutely examined. Specimens of the rocks accompany, which speak for themselves. I am unwilling to obtrude my crude remarks on the Society, but I think the formation round *Pinang*, will be found entirely primitive, though some of the rocks have very little of the appearance of that class. The total absence of organic remains of any kind, the great inclination of the strata, and their immediate connection with granite, I think, lead to this conclusion. The accompanying geological sections will exhibit at one view the succession and arrangement of the strata. In the direction south and north from *Pulo Rimau* to *Pulo Boonting*, a distance of thirty-five miles, we first find granite, then limestone resting on argillaceous rock, then argillaceous schist, and again granite. In the direction from west to east, from *Saddle* Island to *Batta Kawang*, a distance of fourteen miles, we find argillaceous schist, then granite, then argillaceous schist, and again granite.

Should the investigation not prove valuable in a geological point of view, it has at least extended our knowledge of the resources of *Pinang*, by the discovery of the existence of two valuable mineral substances—limestone, including marble, and iron ore, which, should this station ever recover its former importance in commerce, may be of considerable utility.

Pinang, October 18, 1831.

SUPPLEMENTARY NOTE ON THE GEOLOGY OF THE ELEPHANT ROCK, IN THE QUEDAH COUNTRY

During a visit which I made in November last to the capital of *Quedah*, I had an opportunity of examining a remarkable rock, called by the Natives *Gunong Giriyan*, but better known by the name of "the Elephant," given to it by navigators, by whom it is reckoned an excellent land mark. As it has not been hitherto described, and as it is in some measure connected with my former paper, I hope the following brief description of it may not be uninteresting to the Society.



J B Inman Lith.

The country, north of *Quedah* peak, is an immense plain, nearly level with the sea, covered near the coast with rising mangrove, with a very gentle elevation, and bounded to the east by a small chain of hills about from sixteen to twenty miles inland. The breadth of the belt of mangrove along the coast varies from half a mile to a mile. This is succeeded by a narrower one of *ataps*, behind which the country is richly cultivated, laid out in rice grounds, broken every two or three miles by natural boundaries of forest, left most probably when it was originally cleared. The soil is a rich whitish clay, mixed with sand. From the above described plain, at a distance of about six miles from the sea, and about twenty-four in a northerly direction from the northernmost *Pulo Boonting*, rises abruptly the Elephant rock; no hill or other elevated spot being within several miles of it. It is of an oblong shape, apparently about a mile in length from north-west to south-east, and half a mile in breadth: presenting on every side bold and craggy precipices, between three and four hundred feet in height; lofty columnar and needle-like masses being here and there detached from the main body, and shooting up like the spires or turrets of a Cathedral. The top is closely covered with wood, which also rises in some places half way up the precipice, shewing the grey or purplish rocks, in contrast with the foliage, and adding much to its beautiful and romantic appearance. The ground in its immediate neighbourhood is a complete swamp, in which grow a variety of marsh plants which were at this time in flower. A belt of cocoanuts, plantain, betel-nut, and fruit trees of various kinds, extends all round it, and conceals the huts of the Malays which appear to be numerous. A deep ditch, either artificial or natural, surrounds the whole, and renders the approach to the rock extremely difficult, even to elephants, with which the Rajah of *Ligore* had kindly furnished us.

It was the object of our guides to shew us the caves with which the rock abounds, and which, when *Quedah* was of greater consequence than it now is, made it a place of common resort for the natives, more especially the *Chuliah* visitors, who seem to have looked upon it with some degree of religious veneration. We succeeded in crossing the ditch, the elephant sometimes being nearly up to the howdah in mud, and having passed through the cocoanut grove found ourselves near one of the caves. It was not deep, and was formed merely by the over-hanging of the rock. We knocked off some specimens here, and found it to be limestone, close grained, of a dark smoke grey colour, (No. 1). In some places the grain was coarser, the colour deeper; sometimes brownish with minute veins of calcareous spar running through it, (No. 2). Numerous stalactitical masses of a dirty white colour and of immense size, hung from the face of the rock and from the roof of the cave, and when struck with a hammer, gave out a peculiar hollow ringing sound—specimens of these will be found in No. 3 of the series.

Near to this cave there is another, not very deep, but of immense height, the light penetrating at top, through an opening, apparently half way up the precipice. Between these two extending along the base of the rock for some distance, rising a few feet above the surface of the soil, and resting on the limestone, is a bed of reddish yellow cellular calcareous breccia, containing small angular portions of a deep red argillaceous substance resembling that composing *Pulo Sonsong*, formerly described, along with small shells and pieces of coral, (Nos. 4, 5, and 6). In No. 4, near the label, is a distinct impression of a fossil shell, apparently a species of *cirrus (?)* and on attentive examination with a magnifier, others much smaller are readily discovered. We saw the breccia only in this spot; but as we found it impossible, from the swampy nature of the soil, to walk along the base of the precipice, it may exist in other places which we did not visit.

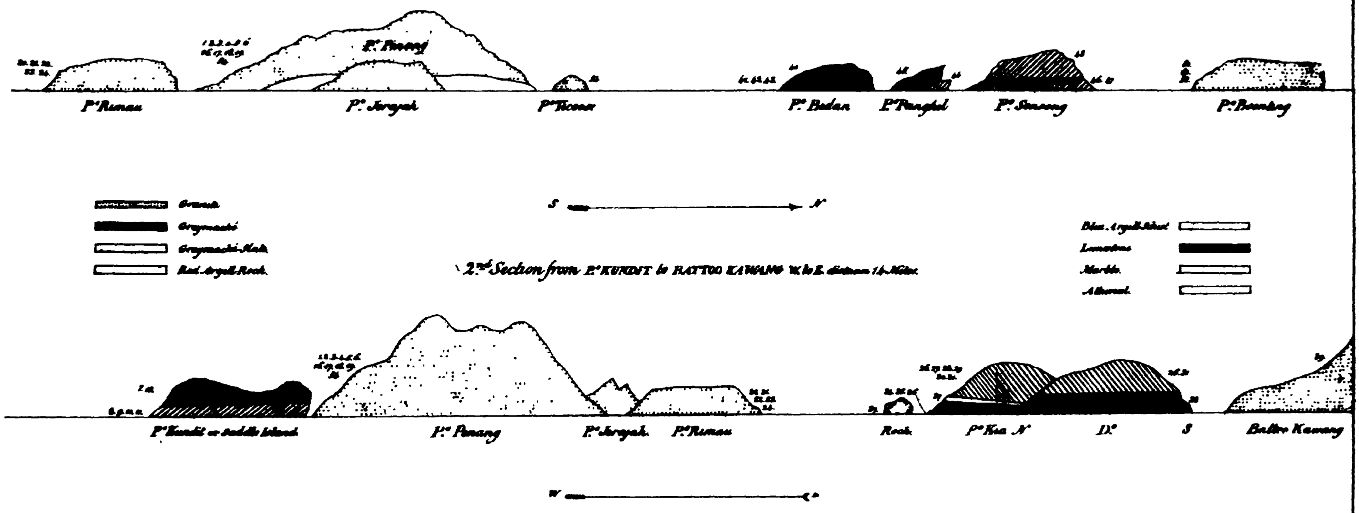
The third cave we came to is somewhat further to the northward It is of splendid extent, apparently one hundred and fifty or two hundred feet in height. The entrance is low, but we ascended a steep slippery road, covered with brown calcareous earth, about sixty or seventy feet, at the top of which are numerous stalagmites, one in particular of a large size, perfectly white, and resembling at a distance a full length marble statue standing on a pedestal. The top of one of a smaller size forms No. 7 of the series. From this point the cave branches off in several directions; the torches cast a lurid glare over the nearer walls, occasionally shewing stalactites hanging from the roof, but the darkness of the more distant passages was impenetrable. So far as we could see, the roof and sides were very irregular, the latter being rugged and precipitous.

The fourth cave is situated apparently at the north-west end of the rock. I say apparently; for not having a compass with us, we were obliged to guess in what direction we went, and on that account I cannot be so correct as I could have wished to be. In our way to it, at the foot of a detached limestone rock, at an elevation of from eight to ten feet above the level of the surrounding plain, we found a mass of shells, principally cockles, oysters, and a larger kind of muscle, connected together by calcareous matter, the interstices being filled with soft earth containing numerous smaller shells, (Specimens 8 and 9). The mass was of irregular shape between three and four feet square, and about the same in thickness, perfectly superficial, and not connected in any way with the rocks near it. No appearance of strata of shells was discovered in the neighbourhood. It will rest with better Geologists than myself to determine whether these are to be considered of a fossil nature, and in this enquiry the nature of the small shells, embedded in the soft earth, may be of material use. Leaving the shells, we ascended about thirty feet among large loose fragments of limestone of the same nature as No. 1, and by a small opening in the rock, entered a dark and spacious cave, which, as the eye became gradually accustomed to the change from the previous glare of sunshine, and distinguished the surrounding objects, appeared to us like a splendid gothic Cathedral in ruins. The walls are worn smooth. as if by the action of water, and covered with a white chalky coating. The roof is dome-like. The stalactitic masses form numerous fret-works, with arched window-like apertures. There are numerous chambers too, and lofty perpendicular passages, some of them admitting light at top, communicating with each other, and producing a pleasing effect when illuminated from within by torches. In places, water is dripping constantly from the roof, but few stalagmites are formed. The floor is nearly level, covered with a brown calcareous earth and with portions of calc-tuff. (No. 10). No. 11 is a specimen of the calcareous sinter, from some of the stalactitic masses,

No sculpture or inscription of any kind was found in the caves. A tradition exists among the natives of the county, that it was at one time surrounded by the sea, and from its general appearance, from the existence of fossil shells in the breccia, and the low nature of the surrounding country, I am inclined to believe that such was the case, and that at no very distant period. It may be remarked also, that it strongly resembles the description of the Limestone Rocks, on the Tenasserim Coast, given by Captain Low.

During the same tour, I had an opportunity also of visiting the nearest range of small hills before mentioned as running parallel with the coast, about sixteen miles inland, and about three miles to the eastward of *Alu Ganuh*, the then residence of the Rajah of *Ligore*. They are so thickly covered with wood, that it is scarcely possible to examine their geological structure. In a few places, however, portions of rock jutted out above the surface, and were found to be formed of a fine kind of sandstone, of which probably the whole range is composed.

1st Geological Section
of
PULO PENANG
and the Neighbouring Islands from P° Rimau to P° Boonting distance 35 Miles



2nd Section from P° KUNDIT to BATTOO KAWANG W to E distance 14 Miles

N.B. The figures refer to the N.os of the specimens sent

J.B. Tanner Lith.

XI.

DESCRIPTION OF THE BUCEROS HOMRAI OF THE HIMALAYA.

By B. H. HODGSON, Esq.

ACTING RESIDENT AT KATHMANDU.

Order, Insessores. Tribe, *Conirostres.* Family, ***Buceridæ.***
Genus, Buceros. Species new.

The Hômrâí Buceros. *B. Hômrâí.* (Mihi.) *Habitat*, The Lesser hills overlooking the plains of India, from the Ganges to the Brahmapútr.

SPECIFIC CHARACTER.

Largest, black, Buceros, with white tail and neck; the wings doubly, and the tail singly barred.

The Hômrâí Buceros (so called by Parbatiahs of *Nepal,*) is the largest species yet discovered of this singular Genus, measuring four feet and a half from the tip of the bill to the end of the tail, and six feet in expanse of wings; and, as all the peculiarities of the Genus are fully developed in this species, their exhibition on so large a scale presents a spectacle calculated to arrest the attention of the most incurious observer of nature.

The Hômrâí tenants the whole of the lower ranges of hills which lie contiguous to the plains, from *Haridwár*, on the west, to *Asám* on the east;

and, following the course of the larger rivers traversing these regions, it penetrates a considerable distance into their mountainous interior; but in such cases always confines itself to the low valleys through which the rivers flow, and never ascends the neighbouring lofty mountains to dwell among them. I have been told, indeed, that the Hômrâí is migratory, that he tenants the lower hills only during the winter and spring, and proceeds northward to the vicinity of the snows on the accession of the hot weather, there to reside during the hot months of the year. But I am inclined to doubt the accuracy of this report, though it came from those who are familiar with the bird during his periodical residence in their limited district, and though I have known a tail feather of the species to be picked up in the woods of *Nepal* proper, where the Hômrâí certainly does not reside at any season; the only feasible explanation of the circumstance therefore seems to be, that the feather in question was dropped by a passenger,—probably, a casual passenger merely.

The district above alluded to is *Dûmjâ*, a small, open, and cultivated tract, at the confluence of the *Rosi* and *Sûn Kosi*, in the interior of the mountains, but communicating by the narrow valley of the latter river with the lesser hills and *Tárai*. *Dúmjá* is low and hot, with a climate like that of the *Tárai*. It is abundantly furnished with fine old Burr and Pipal trees (*Ficus Ind.* and *Religiosa*): and these probably form the attraction which draws the Hômrâí to the spot: for, he loves the lofty perch they afford and is passionately addicted to their fruit. I have received specimens of this species from the neighbourhood of *Haridwár*, from the valley of the *Raptí*, near where it enters the plains—and from *Dûmjâ*; but all procured during the cold season, when alone Europeans can safely enter those malarious tracts. The people of *Dûmjâ* assure me that the Hômrâí frequents their district exclusively in the cold season, and that he migrates northerly towards the close of February, when the heats become excessive. I cannot imagine the species to be truly migratory, but think it probable that it resorts to the valleys during the cold weather; to the *proximate* heights, both for coolness and for retirement in the breeding season, during the hot and rainy months of the year: and, it may be easily supposed to move about from district to district, within the general limits assigned to it by nature, in quest of those various fruits which constitute its principal, if not exclusive food; and thence to appear migratory to the peasantry of any one of these districts.

Having weighed attentively the substance of what is said by Cuvier, by his translator, and by Shaw, respecting the habits in respect to food of the birds of this Genus, I am convinced that there is a great want of well ascertained facts on the subject, and that the prevalent opinion which holds that these birds are, in the main, carnivorous, and feed principally upon small birds, rats and mice, lizards, frogs and even carrion, is erroneous. Mr. Griffith is assuredly mistaken in the supposition "that they do not, in a natural state, *ever take fruit.*" Cuvier, II. 431. Aves. *Imp. Oct. Edi.*

Of the four species with which I am acquainted, I have myself seen two take fruit, in the wild state; and, having subsequently shot them, have found their stomachs filled *exclusively* with fruit.* The remaining two species I never beheld, at liberty, but have kept them, in confinement for months. Both of these showed a great aversion to the frogs and lizards which, in conformity with the prevalent opinion as to their habits, I, at first, offered them. Both always refused to touch mice, rats, or birds: but without manifesting any disgust at the sight of them: and, lastly, both were fed entirely, after testing their palates, upon fruits and boiled rice, as that sort of food which was found to be most agreeable to them, though both would still eat fresh good meat, either raw or dressed, when vegetable diet was not within their reach

---

* A common Indian species, different from either of these, was described in the Asiatic Society's Transactions so long ago as the time of Sir W. Jones; it is stated to be frugivorous in the state of nature, and to feed upon the nux vomica, voraciously, so long as such food is procurable. Mr. Stirling notices the same fact in his account of Cuttack, in the 16th vol. of the Researches.

No offensive odour exhaled from the bodies of any of these four species, and the flesh of all was wholesome and pleasantly flavoured; facts which seem to me decisive as to their *never* feeding on carrion, or even, on such living animals as lizards and frogs.

Is there a single bird or beast among the *carnivora*, the flesh of which is wholesome and agreeable to our taste ?

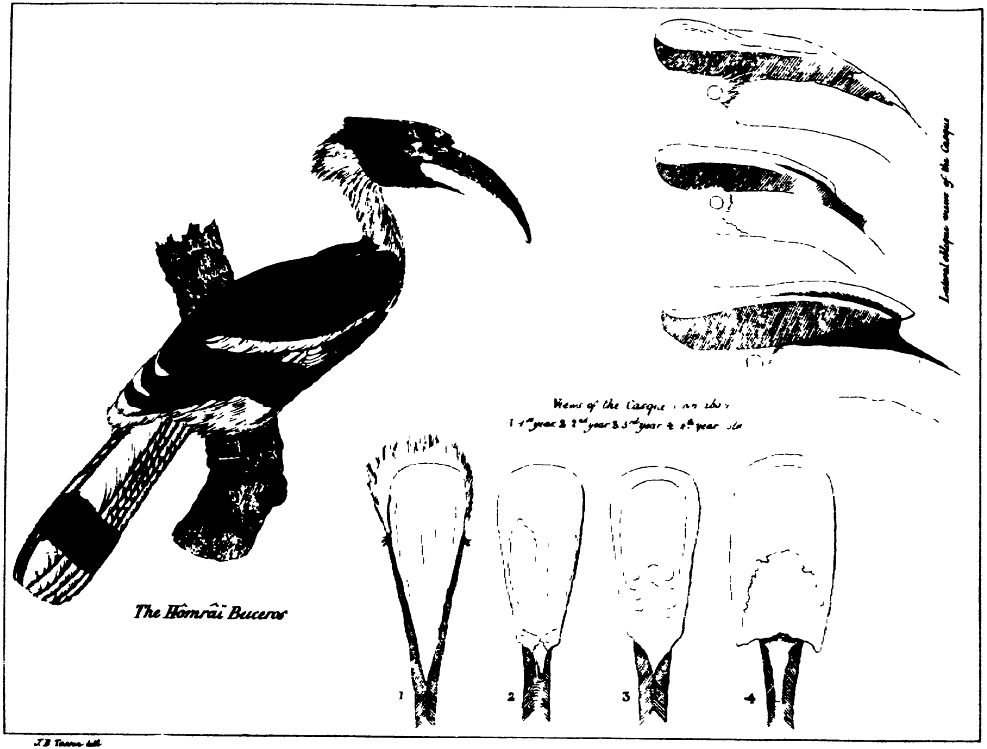
With respect to rats, mice, and small birds, it appears to me that so awkward and inagile a creature as the Buceros (any of the species) must soon die of hunger if he were obliged to sustain himself by the capture of such nimble prey.

Indeed, the whole *external* structure of the birds of this Genus affords a strong presumption against their being carnivora—except in the *meanest* sense: and against their feeding on unclean reptiles and carrion, the absence of offensive odour from their bodies and the wholesomeness of their flesh, to my judgment, are conclusive.

What arguments might be drawn on either side from their *internal* structure I am not anatomist enough to say, and I regret I could not afford Dr. BRAMLEY* an opportunity of judging. The character of the stomach and intestines of a large species which forms the subject of the

---

* To the kindness of this gentleman I am indebted for the anatomical observations upon the Hômrâí which are given in the sequel. Imperfect though they be (circumstances not admitting of a regular dissection of the bird) they will I am sure be acceptable and highly valued by every true ornithologist—most works on the subject, and especially English works, being sadly deficient in this important kind of information.



The Hômrâï Buceros

Views of the Casque [illegible]
1 1st year 2 2nd year 3 3rd year 4 4th year etc

Lateral oblique views of the Casque

J B Tassin lith

present paper is, I believe, doubtful: but I can only say that the stomach is single, simple, pretty capacious, thin in its coats, and possessed of very moderate rugosity on its internal surface; and that the intestines are rather less than three times the length of the body, from the occiput to the rump; not obviously distinguishable, by difference of size or otherwise, in the different parts; and of such capacity or diameter as just to admit the insertion of the fore finger. I fear that the foregoing remarks respecting the habits in respect to food of the birds of this singular Genus will, to some, appear tedious and prolix. But whoever is aware of the strict analogy between structure and habits which prevails throughout animated nature, will receive indulgently every attempt to remove errors as well as to contribute facts relative to the most important of the habits of a large groupe of birds which are so singularly formed that we are apt to regard their structure as monstrous and anomalous.

I proceed now with the description of the species before me, of which I possess ten specimens, showing both sexes in maturity, and the young in various stages of progression towards it. From a comparison of these I am led to conclude that the body of the Hômrâí does not reach its full size under two or three years, and that the bill and casque, especially the latter, are not perfectly developed in less than four or five years.

At birth, the young have no casque. The developement of this appendage to the bill commences from behind; and, in the posterior part, is tolerably distinct as to form by the close of the first year; whilst, anteriorly, there is no distinction but that of colour between the casque and the ridge of the bill. In the second year, the fore part of the casque begins to rise and spread itself out above the bill; but does not acquire its full dimensions and characteristic shape till the fourth or fifth year, as will be more particularly noticed hereafter in speaking of the young.

This species is gregarious, like most others of the Genus; of staid and serious manners and motions; full of confidence and quietness; and seeming to prefer the few open and cultivated spots in the wilds it inhabits—which spots are usually limited to the banks of rivers. There, perched on the top of some huge, fantastic *Bar* tree, you shall see this large, grotesque, and solemn bird sit motionless for hours, with his neck concealed between the high shoulders of his wings, and his body sunk upon his tarsi; the very type and emblem of the orient world!

Occasionally, he will take a short flight accompanied by one or two companions (for he is a social bird,) to some other high tree; never, so far as I have observed, alighting on the ground, nor on a low tree. Twenty or thirty birds are commonly found in the same immediate vicinity—six or eight, upon the same tree, if it be large. And they will continue perched for hours with the immoveable gravity of judges, now and then exchanging a few syllables in the most subdued tone of a voice as uncouth as their forms and manners.

This subdued articulation is not louder than, and is similar in character with, the low croaking of a bull frog. But, if the remorseless gunner intrude upon this solemn congress and bring down, without mortally wounding one of its members, the clamours of the captive bird will utterly amaze him. I cannot liken this vehement vociferation to any thing but the braying of a jackass:—its power is extraordinary, and is the consequence of an unusually osseous structure of the rings of the trachæa and of the larynx. The Hômrâí flies with his neck stretched out, his legs retracted, and his tail levelled and somewhat expanded. His flight is straight and laborious, with heavy uniform frequent motion of his wings, which, though ample in size, have not apparently a corresponding degree of energy:—I presume so, from the short, straight, and laborious flight of the Hômrâí; and Dr. BRAMLEY infers the same thing from the lax concatenation of the vertebræ of his back.

With respect to food, my impression is that the Hômrâí is almost exclusively frugivorous. That he is altogether so, *at certain seasons*, is unquestionable; for, out of six birds which I opened in January and February, there was not one the stomach of which contained a single particle of any thing but the fruit of the ***Pipal*** tree.

When and how the Hômrâí nidificates, I cannot ascertain: but I presume that his habits in respect to breeding are similar to those of the *Buceros Nipalensis*, a species of nearly equal size, tenanting the same region which I described four years ago in the Society's Transactions. And it may be observed, that this peculiar nidification explains the serious injury done to the bill; which nothing that is known of the bird's habits in respect to food will, in the least, account for. The mature male of the Hômrâí species measures four and a half feet long, and six feet in width between the wings.

The bill is nearly a foot in length, of straight measurement,—considerably more, if measured along the curve; and the tail is one and a half foot. The bill and casque are both extremely large, and bear a close resemblance in their forms to those of the *Bifronted Buceros* The legs are short and stout, and the feet exhibit the perfection of that peculiar structure which induced CUVIER to separate his Syndactyles from the promiscuous heap of the Passerine birds. The body is full and plump, but very small in proportion to the size of the extremities. The neck is as long as the body, the vertebræ being large in size, though few in number. It is a long, lank bird, of uncompact structure, almost helpless on the ground, and of but limited power on the wing, with feet incapable of grasping, in the raptorial sense, but admirably suited for laying a strong hold upon the larger branches of those tall trees in which the species seem to spend nearly their whole lives—feeding and roosting in one and the same place, and having no necessity to go abroad in search of water, since they never take it.

The bill is extremely large, cleft to the eye, smooth, hard, considerably arched throughout, much compressed, except at the base, where it is as broad nearly as high, the cutting edges broken and separated in the central parts of the bill, closed and even towards the extremities, but not interlocked. The cutting edges are composed of a separate brittle substance, which, in the perfect bill, is furnished with serrations. But as these serrations, together with most of the substance containing them, are not developed in the young bird and are soon, for the most part, destroyed, nor ever afterwards replaced, in the maturer one, it is as difficult precisely to define them as to conceive the purpose for which they were intended.

The hard substance in which these serrations are cut, likewise lines the whole inside of the bill, and is never itself entirely destroyed on the cutting edges, though the teeth-like processes are: its entrance into the composition of the bill, must give the bill considerable additional power.

The palate is placed near the cutting edge of the upper mandible: in the lower mandible it is remoter, except near the tip, where, as in the upper one, the palate lies in contact with the cutting edges of the bill, both mandibles of which are nearly solid towards their forward extremities. A sharp ridge runs down the entire centre of the inside of either mandible. The upper and lower mandibles are of equal length, and rather sharply pointed.

The casque is rested on the basal part of the bill and on the cranium, passing beyond the posterior boundary of the latter more than an inch and a half. Its most forward point is about four inches before the eye; its most hindward three and three-quarter inches behind it. From the tip of the bill to the forward point of the casque, nine inches. The casque is frail, hollow, very large, flat topped, broader than high, as broad almost before as behind, its upper surface level with the margins, posteriorly dipped between them, and inclined towards the ridge of the bill, anteriorly;

squared behind, concavely crescented before, with the horns of the crescent elevated one inch above the bill, and directed forwards and downwards with a slight curve parallel to the bend of the bill: the posterior edge of the casque, full, rounded, and soft; the lateral and anterior edges, spare and hard.

The nostrils are small, subtriangular or irregular oval, transversely cleft, placed at the base and top of the bill, where it joins the casque, and covered with incumbent reflected setaceous feathers.

The tongue is fleshy, flat, small, with point entire; its position, the bottom of the throat.

The head is small; the parietal and occipital bones, firm and solid; those of the anterior parts of the skull, cellular and feeble; the occiput, strikingly defined and furnished with large transverse and vertical cristæ; the orbits, medial and almost entire. Both eyelids have strong bristly lashes, the upper being the stronger and conspicuously flattened or depressed. The tail is long and rounded slightly, consisting of ten very broad, strong, feathers of nearly equal length, but the laterals somewhat shorter than the centrals, and subgradated from below.

The wings of medial length, high-shouldered, rounded, acuminated, the sixth quill longest; the fifth and seventh nearly equal to it; the first and second much smaller, narrowed, sharp, and incurved; the longest primaries and longest secondaries, equal; the tertials and scapulars, small.

The legs and feet very stout. The tarsi, low; knees plumed before; acrotarsia, brokenly and heavily scutellated; posterior and lateral surfaces of the tarsi, covered merely with coarse reticulated skin; the toes, of submedial length, depressed, broad, shielded by a single row of transverse heavy scales, and of strictly gressorial or syndactyle character; the nails, arched, compressed, obtuse.

The dimensions will be given in detail in the sequel. The colours are as follows:

The casque and upper mandible of the bill, deep waxen yellow, merging, more or less, into rich red, on the top of the casque, and towards the tip of the upper mandible; the tip itself, and the lower mandible, ivory white; base of both mandibles, anterior and posterior surface of the casque, a line along the ridge of the bill, its cutting edges, and the whole inner surface of the bill, black; iris, intense crimson; legs, deep obscure green; nails, blackish; naked skin round the eye, full black; body and wings, subterminal bar on the tail, chin, and junction of the head and neck, black—the body above and wings, feebly glossed with green—the rest, unglossed; neck, yellow-tinged white; tail, pure white, with a broad black bar crossing it entirely at the distance of three inches from the lower extremity: all but the two first quill-feathers of the wings, broadly whitened at either extremity; tips of the long coverts, also white, forming altogether two conspicuous white bars on the wings: vent, rump, thighs, legs, and upper and under tail coverts, dirty white. The unctuous secretion from the rump is of a yellow colour; and, either with this, or with a local secretion of the same kind, several of the prime quills are dyed on the white part of them, going to form the upper bar of the wings. Why this spot should be thus dyed, and no other part of the plumage, I cannot imagine: but note the fact, because all my specimens agree in respect to it.

The whole plumage of the head, neck, inferior surface of the body and of the thighs, is lax, discomposed, and more or less setaceous; that of the hind head being also somewhat elongated, forms a slight drooping crest. The crest and the neck feathers, the bird erects partially when much excited. The female and young of a year old have the legs and plumage coloured exactly like the male; from which the former differs by being smaller; by having the irides of her eyes, pure hoary; the naked skin of the ophthalmic region, pale purpurescent dusky; and lastly, by wanting the black colour which distinguishes the casque, and ridge, cutting edges, and interior surface of the bill, in the male; those parts of the casque and bill of the female, being red, like the subterminal portion of the upper mandible of both sexes. The mature female's bill and casque are shaped like those of the old male, but are both smaller in proportion. The young have the bill much less arched, and thicker in proportion to the length; the cutting edges are entire, void of brittle substance or serration; and there is no casque, or rather the casque has no developement or separation from the bill, anteriorly: for, posteriorly, it has both, very soon after birth. In the second year the anterior portion of the casque begins to separate itself from the ridge of the bill, exhibiting a wedge form; the apex of which, gradually receding during the third year, in proportion as the casque acquires more breadth and height in front, comes at length, in the mature state to form the centre of that inward curve or crescent, the ends of which are the *horns* of the old bird's casque. The younger the bird, the narrower the casque in front. Old age alone makes it nearly as broad before as behind. The sketches appended to this paper will complete the illustration of this point, which is of importance as a guard against the multiplication of imaginary species, derived solely from diversities in the shape of the bill and casque. The bill of the young is at first of an uniform pale greenish yellow, with a small portion of black at the base only. Their iris, whatever the sex, is at first, hoary, like the females; and the ophthalmic region, pale dusky. *Posteriorly*, their casque is soon darkened, if they be males—reddened, if they be females: but the black or red space defining the separation of the casque and bill, *anteriorly*, is later manifested; because its manifestation depends upon the developement of the casque itself in that the last developed part of it.

The black or red (according to sex) of the cutting edges begins to show itself before the close of the 1st year, and is as abundant in quantity, though less intense in hue, in the 2nd year as ever afterwards. Indeed, the brittle edging of the bill, which is alone thus coloured, no sooner is perfected than it begins to be rapidly destroyed, together with the serration which belongs to it—an enigmatical circumstance—like, indeed, every other connected with the purpose and use of this most remarkable organ.

Dimensions of the mature male and female.

	MALE.		FEMALE.	
	Ft.	*In.*	*Ft.*	*In.*
Tip of bill to end of tail,	4	5½	4	0
Bill, length of,	0	11¼	0	10½
Ditto basal height of,	0	3	0	2¾
Ditto basal breadth of,	0	2½	0	2¼
Length of the casque,	0	7¾	0	6
Utmost height of ditto,	0	1⅞	0	1 6/8
Utmost breadth of ditto,	0	3½	0	3¼
Length of the tail,	1	6¼	1	6
Expanse of the wings,	5	10	5	5
Length of the tarsi,	0	3⅛	0	3
Length of central toe and nail,	0	4	0	3¾
Weight of the bird,	8½*lbs.*		7½*lbs.*	
Weight of the bill and skull,	8¼*oz.*		*caret.*	

VALLEY OF NEPAL, *February*, 1832.

REMARKS ON THE SKELETON OF THE HOMRAI BUCEROS.

The Bill consists of horny matter of considerable thickness, which lies in close adaptation with the osseous structure beneath, and is connected with it by means of a membrane, over which numerous small blood vessels are distributed.

The casket, (which is of large dimensions) has also its horny covering, though somewhat different in structure, that of the former being laminated, and bearing a close resemblance to proper horn, while that of the latter is much thinner, of a fibrous consistence, and nail-like in structure. The edges of the bills, of both mandibles, for about two-thirds of their length from the point, are horny, but the surface is so irregular and jagged, that their appearance leaves no doubt that much of the natural structure has been broken off, by the use which the bird makes of its bill. In consequence of this, when the jaws are closed, there is a considerable vacancy between the cutting edges throughout the whole central portion of the bill. In some specimens in Mr. Hodgson's Collection the fractures have taken place at such regular intervals, as to give to these parts the appearance of natural indentations.

To entertain this supposition, however, would be erroneous, as there is evident reason to believe that in a bill, which is perfect, the horn by which it is covered does not extend to its edges, but terminates just before it arrives at these, in a substance not very much unlike solid bone. The chief difference from the latter, is, that it is exceedingly brittle in its nature, though it is by no means deficient in compactness.

That this substance borders the edges of both mandibles in their natural state, is confirmed by numerous portions which are here and there left, in all the specimens I have examined. There is, also, a distinct line along the bills denoting the termination of the horn, into this hard structure, which in some individuals is of a red colour, and in others, a black.

There is no trace of reproduction, after a portion has once been destroyed, and so much of it is lost in early life, that in the mature bird, the only portion which remains perfect, is that which is situated nearest the cranium. In six out of seven of these birds which I have examined, all those remaining portions of sound bill, have certain serrations on their edges, which proceed from this hard substance: in none, however, were they arranged with sufficient regularity, to admit of description, except in the individual from which these notes are chiefly taken. In this four very distinct ones, may be said to exist on the lower mandible, the interval between them being so uniform, and their shape so similar, as (from appearance alone) to warrant the conclusion, that they are natural productions. In the seventh specimen, however, (which was a young bird supposed to have been hatched last rains,) these serrations are not visible in either mandible. Whether (in the perfect bill) these tooth-like processes always exist, I will not pretend to determine. If they should be found to do so, it would at least, become a matter of question, for what purpose they are destined.

The circumstance of the birds being deprived of a greater portion of the hard substance constituting the edges of the mandibles, in early life, never afterwards to be replaced, is a strong evidence that such formations are not necessary in aiding them to secure their food, moreover their presence would not correspond with the supposed natural habits of birds of this class; and, furthermore, as there are no corresponding depressions in the opposite jaw, and as the birds live very well without them, it is reasonable to conclude, that the existence of serrations on the edges of the bill must be denied, as necessary formations, while to account for their presence, the exceeding brittleness of the substance on which they are situated deserves consideration.

The osseous structure beneath the horn, as will be apprehended from the enormous size of the bill, is very light, and cellular throughout, The same structure is also observable in the bones, at the base of the skull. The casket on its interior exhibits nothing but innumerable, and minute processes of bony matter, which intercept each other, so as to form a reticular arrangement. The upper mandible is firmly joined to the skull, and admits of no motion whatever. This variety (which is met with in very few birds) may be accounted for in the present species, by the large casket being fixed to the bill, and resting posteriorly on the vertex of the cranium. If therefore the upper mandible was moveable, the casket would become subject to the same motion. The orbits, when compared with those of most birds, are small. There is no trace of a bony septum between them, but their division is effected by a membraneous partition.

The cervical vertebræ are twelve in number. They are articulated to each other by means of small eminences, which constitute real joints. This provision, which is common to all birds, gives to them that peculiar freedom of motion in the neck, which the whole class more or less possess. In the Buceros this motion is considerably restricted, in consequence of the firmness with which the ligaments bind these vertebræ together, particularly the large one which passes along the proterior part of the neck, and attaches itself to the spinous processes.

There are seven dorsal vertebræ—which are articulated to each other by synchondroses, or plane joints. They are all separated, but the first three are so firmly connected by ligamentous structure as scarcely to admit of any motion; the remaining four are more loosely joined.

It may here be noticed, that as the dorsal vertebræ of this bird are all moveable, it becomes a matter of question whether its power of flight is in any way remarkable. Except in birds which do not fly, as the Ostrich, &c. it is by no means common to meet with examples, where the dorsal vertebræ are all separated; two or more of these are generally found to be anchylosed at their spinous processes, or the whole of this part of the spinal column may be rendered fixed and immoveable, by the connecting ligaments being substituted by bone, as is very generally the case in birds possessing any extraordinary activity on the wing, or extensive power of flight.

This immoveable structure of the *dorsal* vertebræ of such birds is believed to be necessary to give support and steadiness to the trunk, during their varied and violent motions in flying; and BLUMENBACH affirms that the want of motion inseparable from it, is compensated by a larger number, and greater mobility of the *cervical* vertebræ.

In consistency with this supposed system of compensation, the Buceros which has dorsal vertebræ capable of considerable motion, has but a small number of cervical vertebræ,[*] and those rigidly connected. From this structure I infer the limited power of the Buceros on the wing.

The lumbar vertebræ, as is usually met with in birds, are all anchylosed. The remains of the three first are visible, but their total number cannot be ascertained. The tail consists of eight bones. The last of these is the largest, its greatest length measuring 2¼ inches by 1⅜ in breadth.[†] All the bones have large transverse processes. They have also spinous ones situated posteriorly, and the three last bones, have in addition these processes arising from their anterior surface.

There are seven pairs of ribs, namely, six pairs of true ribs, and one pair false, i. e. not attached to the sternum. The true ribs are joined to the sternum by intermediate bone.

The pelvis is similar in formation to that of birds in general, except in those which have it closed in front. The length of the os innominatum is 4⅛ inches, and 2⅜ inches broad.

---

[*] This bird has the same number of cervical vertebræ as the raven, and one less than the cock.

[†] The dimensions of this bone are noticed in consequence of the bird being observed to erect and expand its tail feathers.

The sternum measures in length 1 inches, and in breadth 2⅜ inches. The large crista which is situated on its centre and anterior surface is continued down the whole length of the bone—and is elevated above the sternum at its most superior part 1½ inches. At this point is united the os jugale, (merry thought) the cornua of which proceed outwards and upwards, and nearly parallel with the two large clavicles, to meet the scapulæ at the point of either shoulder, where these three bones become united by ligament, and form the glenoid cavity of the Humerus.

The wing is composed of the following bones. 1st. The brachium—which measures 5½ inches in length. 2ndly. The two bones of the fore-arm (cubitus) in length 8½ inches. On the largest of these bones are fourteen small prominences, arranged longitudinally, which denote the attachment of the quills of the secondary feathers of the wing. 3rdly. Two small bones of the carpus. One articulated by firm ligamentous structure to the end of the small bone of the fore-arm. The other is attached to the large bone, by means of a long tendon, which is inserted at about the terminal third of this bone, and it is joined to the metacarpus just below its articular surface by ligaments. This bone is situated in the bend of the wing, and plays on the outer condyle of the metacarpus. 4thly. The metacarpus consists of two bones consolidated into one at either extremity, and open in the centre. It measures in length 2⅝ inches. 5thly. The thumb (false wing) formed of one small bone, articulated to the metacarpus on its edge, and immediately below the carpal joint. 6thly. The two fingers, that which lies on the same line with the thumb, has two phalanges, the other but one.

The Leg. The first of these bones is the femur, in length 4 inches. 2ndly. The tibia and fibula. The former measures 5½ inches in length. The fibula, which can scarcely be said to exist, in most birds, is very distinct in this. It enters into the formation of the knee joint, and completes the outer border of the articular surface, part of the outer condyle of the femur resting on it.

The breadth of its articular surface is $\frac{3}{8}$ of an inch. From this it is continued down the outer edge of the tibia, but has no osseous connection with this bone, for $2\frac{3}{8}$ inches in its extent, here the two become consolidated, and towards the termination of the bone, above the articulation, a small speculum of bone arises from the tibia, which denotes the termination of the fibula. 3rdly. One metatarsal bone (answers to the tarsus) $2\frac{7}{8}$ inches in length. To this the toes are articulated. There is also another which is attached to the metatarsal bone, by a broad synchondrosis, and proceeds obliquely outwards, for the exclusive attachment of the great toe. This bone has been observed in some birds of the Parrot kind, and I can testify its existence in the foot of the King-fisher. It is difficult to convey an adequate description of its shape. In the present bird (Buceros) it is nearly an inch in length, and half an inch broad at its articulation to the great toe. It has two prominences on its articular surface, resembling condyles, the inner one being twice the size of the outer. To meet these, there are corresponding concavities at the base of the first phalanx of the great toe, by which a very perfect joint is formed. There is a groove in the metatarsus in which the base of the small bone is lodged. 4th. The toes. The great toe has two phalanges. The one next to this has three, the middle toe four, and the last has five.

Memorandum concerning the anatomy of the tongue and vocal organs of the Hómrái Buceros

The tongue consists of a small fleshy substance of triangular form, and measures about $\frac{3}{4}$ of an inch in length, by $\frac{1}{2}$ an inch in breadth.

On its superior surface, and towards its base, several small cartilaginous processes are seen with their points directed towards the throat. Its edges, on this part, are also barbed by similar structures.

There are no papillæ observable on its surface, nor can it be considered an organ of taste, since it is so firmly connected to the sheath of the lower mandible, as to admit of little or no elongation even with the aid of considerable force, which I applied very shortly after the bird was shot.

The tongue terminates by a strong fleshy attachment to the os hyoides, and is further connected to this bone, by a process of cartilage which arises from the body, or centre portion, of the latter, and becomes embedded in the muscular structure of the organ to about half its length.

The os hyoides consists of five distinct bony portions ; viz. The body or centre portion, and two pairs of cornua. The first pair of the latter are attached to either side of the body ; at the ends of these commence the second pair, the two being joined together by synchondrosis. Their united length on either side is three inches. The second pair terminate by two round cartilaginous ligaments, which measure ¼ of an inch in length.

Besides the cartilaginous process which arises from the body of the os hyoides, and gives attachment to the tongue, there is a similar one which proceeds from its inferior edge, which is loosely bound to the posterior surface of the trachœa by bands of ligamentous structure.

The superior larynx is formed anteriorly and latterally of bone, its posterior part being completed by membrane.

The annuli of the *Trachæa* are all more or less ossified, and there is also a bony addition at the inferior larynx, which latter may probably be the same as that found in some of the Mergansers.

M. J. BRAMLEY.

XII.

ON THE
COMPENSATION MEASURING APPARATUS
OF THE
GREAT TRIGONOMETRICAL SURVEY OF INDIA.

BY CAPTAIN EVEREST.
Bengal Artillery,
FRS MAS FGS &c SURVEYOR GENERAL, AND SUPERINTENDENT OF THE
GREAT TRIGONOMETRICAL SURVEY OF INDIA

[*Being the substance of a Lecture delivered in illustration of the Measuring Apparatus, before the Physical Class, on the 11th March, 1831.*]

NOTHING seems easier, at first sight, than to measure a straight line. If, for example, it were wanted to ascertain the length of the room we are in, or the table at which we are seated, the mode commonly used on such occasions would be to take a foot rule and try how many feet and inches it was, and this would be quite a sufficient solution, provided that there was no further object in view. But suppose it were necessary, for any particular purpose, to know the exact relative lengths of two rods or bars, one of which had been determined in the national measure of France, and the other in that of Great Britain. Here, at first sight, is a very different state of the case, for the English rod has been measured with a foot rule, and so has the French; but though they should be of perfectly equal size, the lengths would not be expressed by the same number.

Now, therefore, it will be necessary to enquire a little further into first principles; and let us think for a moment what is a foot? The definition of a foot is twelve inches. But what is an inch? Three barley-corns make an inch, as we are told at school; but unless it can be shewn that the ears of barley in France have grains longer than those of England, it will be difficult to shew why the French foot is longer than the English, as it actually is, in the ratio of seventeen to sixteen nearly.

Our enquiries will lead us at last to the conclusion, that what is called the standard yard of Great Britain is not in itself a very determinate quantity; for take several carpenter's rules and compare them, and two of them will hardly ever be found alike; or take several brass Gunter's scales, as they are called, made by different makers, and they will by no means correspond with each other, nor is it easy to conceive how they ever should, for the old standard of reference, which was three grains of dry barley, must vary from causes almost innumerable. Indeed, in respect to national measures we owe no thanks to the wisdom of our ancestors.

Every country in Europe has its own particular measure. We have the Roman palm, the braccio of some parts of Italy, the ruthe of Dantzic, and numerous others. Most countries, however, use the term foot, because it is supposed to have some relation to the part of the human frame most easily accessible, and whether it is owing to what are called the degenerate modern days, or whether the foot originally was taken as a standard of reference with a shoe on it, certain it is that twelve of our inches, now-a-days, would be rather a longer foot than suitable to ornament or utility.

It will hardly be credited, yet it is an actual fact, that there are in Europe alone upwards of a hundred different national measures, no two of which had, until lately, their relative values thoroughly known; but if this should seem matter of surprise, still more extraordinary must the fact appear, that until Captain KATER's experiments, there were measures bearing the same denomination in our own country, none of which corresponded, so that every instrument maker, when he constructed what he called a standard scale, meant his own standard, which he had either arbitrarily fixed for himself or inherited from his predecessor.

The want of a determinate idea as to the measures of antiquity, has always been a subject of perplexity to Historians,—in fact, in consequence of that defect, all the geographical details which we derive from that source are a maze of conjecture for the ingenious to build airy hypotheses in. Perhaps, however, this system, incongruous as it is, might have been sufficient to answer the ordinary purposes of life, and, if the question had never been started respecting the figure of the earth, would, in all probability, have been but little agitated, if at all.

This was at first a mere speculative question: it had been found by M. RICHER, a French mathematician, who went to make astronomical observations at Cayenne in 1672, that the pendulum of his astronomical clock, which had been adjusted to mean time at Paris, lost above two minutes every day, and he was obliged to shorten the pendulum one-tenth of an inch to make it keep time in the latitude of 4′ 55″. Such was the state of science at that period, (and we are not yet two centuries removed from it,) that when he drew conclusions from this respecting the diminution of gravity, his opinions were scouted by almost all the Philosophers of Europe. HUYGENS was the first person who gave the subject fair consideration, and as he brought with him an overpowering array of mathematical reasoning, combined with inexhaustible patience, he soon discovered that pendulums must vibrate slower as they approach the equator; but even HUYGENS could not solve the difficulty of assigning the form which the earth must assume. He made what we should call the two

Now, therefore, it will be necessary to enquire a little further into first principles; and let us think for a moment what is a foot? The definition of a foot is twelve inches. But what is an inch? Three barleycorns make an inch, as we are told at school; but unless it can be shewn that the ears of barley in France have grains longer than those of England, it will be difficult to shew why the French foot is longer than the English, as it actually is, in the ratio of seventeen to sixteen nearly.

Our enquiries will lead us at last to the conclusion, that what is called the standard yard of Great Britain is not in itself a very determinate quantity; for take several carpenter's rules and compare them, and two of them will hardly ever be found alike; or take several brass Gunter's scales, as they are called, made by different makers, and they will by no means correspond with each other, nor is it easy to conceive how they ever should, for the old standard of reference, which was three grains of dry barley, must vary from causes almost innumerable. Indeed, in respect to national measures we owe no thanks to the wisdom of our ancestors.

Every country in Europe has its own particular measure. We have the Roman palm, the braccio of some parts of Italy, the ruthe of Dantzic, and numerous others. Most countries, however, use the term foot, because it is supposed to have some relation to the part of the human frame most easily accessible, and whether it is owing to what are called the degenerate modern days, or whether the foot originally was taken as a standard of reference with a shoe on it, certain it is that twelve of our inches, now-a-days, would be rather a longer foot than suitable to ornament or utility.

It will hardly be credited, yet it is an actual fact, that there are in Europe alone upwards of a hundred different national measures, no two of which had, until lately, their relative values thoroughly known; but if that an increase of density in the earth, from the surface to the centre, would be attended with a greater protuberance at the equator than in the cases of homogeneity.

As it is not an object to enter into a minute investigation of this abstruse question at present, this part of the subject may be dismissed with the name of M. Clairaut, who first fully considered the question of the figure which a planet must assume with a density gradually increasing from the surface towards the centre.

The theory of Sir Isaac Newton was not well received at first—it impugned the doctrine of the vortices of Descartes, which was then in high favor in France. M. Picard had measured an arc of the meridian in France between Amiens and Malvoisine about 1°⅓ of the quadrant; MM. Cassine, De la Hire, and others, resumed this, and continued it through the whole extent of France in several sections, which were finished in 1718, and it was found that the lengths of the degrees diminished as the latitudes encreased, which rather tended to give an elongated than an oblate form to the globe. This was afterwards found to result from errors of computation, but since the comparison of contiguous degrees is not the best way to determine with great accuracy so very small a quantity, as the compression would be, the Government of Louis XV. resolved on fitting out two expeditions, one of which should measure an arc as near the equator and the other as near the pole as possible.

It was in 1735 that MM. Bouguer, De la Condamine, Godin, and several assistants and artists on the part of the French Government, accompanied by Dons Juan and Ulloa, on the part of that of Spain, went to Quito, in Spanish America, and at the same time the northern expedition under MM. Maupertuis, Clairaut, Mounier. Camus. Celsius, and others went to Torneo in Lapland—permission having been obtained from the Swedish Government for that purpose.

Both these expeditions were fitted out with the best instruments then to be obtained, at the expence of the French Government. The operations under the equator occupied upwards of ten years, and those of the polar circle about two.

One cannot too much admire the determination and constancy with which the French Government seems to have been actuated on that occasion. The *onus probandi* did not lie with them more than with us, perhaps not so much so—nature and fortune had bestowed upon England the greatest philosopher mankind ever saw, and our ancestors must bear the reproach of having neglected as unworthy of them that pre-eminence in science, which had it fallen to the lot of any other nation in Europe, would have been looked on as a high source of pride. It is very true Sir ISAAC NEWTON was recompensed, whilst living, by a lucrative post at the Mint, and it is equally true that monuments have been erected to him in Westminster Abbey, and elsewhere ; but the best monument which a grateful country could have bestowed on this most eminent and distinguished of her sons, would have been to establish the truth of the doctrines he had promulgated by actual experiment, instead of leaving them entirely to the mercy of strangers.

Not to dwell too much upon these preliminary matters, it will now be advisable to explain what the figure of the earth has to do with the subject on which we started, for it is desirable to show that this is not merely a speculative point for the philosopher to amuse himself with in his closet, but one of actual practical utility, according to the conception which I have of the meaning of that term.

If it be conceded that geography is useful—then there is no pure source from which we can draw our elements, but this Let us measure a distance on the earth's surface by the primitive mode of the drying of a wet leaf,[*] the more modern method of the duration of a smoking pipe,[†] by pacing, by chains, by rods, by perambulators; we must (do what we will) for geographical purposes reduce the distances so found to degrees, minutes, and seconds, of latitude and longitude. But unless we know how many miles, or feet, or pipes, go to the degree, the mode of comparison is wanting to complete the reduction.

If the earth were quite spherical, all degrees of latitude would be equal, and all degrees of longitude would vary as the cosines of the latitude, but that is not the case if it be compressed at the poles, for the length of degrees of latitude would then increase as we recede from the equator, and the length of degrees of longitude would cease to vary in the above proportion.

There is a class of people who will reply to this that we have only to look into any elementary book on arithmetic, and there we shall find that sixty-nine and a half British miles make a degree;—the same gentlemen, amongst whom Mr. COBBETT has occasionally figured, whilst the humour was on him, together with many others as far surpassing him in rank as he does them in intellect, will be ready to declare that pounds, shillings, and pence are the only useful knowledge, and that tare and tret, and bills of parcels, are the fittest boundaries to limit the mathematical education of Englishmen. We all must recollect M. VOLTAIRE's story of JEANNOT and COLIN. How the young JEANNOT suddenly became raised to the peerage from being a peasant, and how the father and mother of JEANNOT discussed with his governor what he was to be taught, but that author must be left to speak for himself, for it is impossible to improve upon his delicate irony by any description.

---

[*] A practice common with the *Hindoos*.

[†] The Dutch boors at the Cape of Good Hope commonly estimate by this method. I am told the natives of the hills near *Assam* do the same.

"Mais qu' apprendra-t-il donc? Car encore faut-il qu'il sache quelque chose; ne pourroit-on pas lui montrer un peu de geographie? A quoi cela lui servira-t-il? repondit le gouverneur—quand Monsieur le Marquis ira dans ses terres, les postillons ne sauront ils pas les chemins? ils ne l' egareront certainement pas."

We are all acquainted with what is called the precession of the equinoxes. The mean annual precession is the joint effect of the Sun and Moon, acting on the protuberant portion of matter about the equator, and is determined by finding how much any particular star has retrograded in right ascension, by a comparison of observations made by the older astronomers with those made in recent days.

But BRADLEY never would have been able to separate the inequalities which he detected only in heaps and parcels into the atoms of aberration, Solar and Lunar nutation, and inequality of precession, unless he had had an approximate value for the excess of matter at the equator, and it cannot be doubted for a moment that the nearer we approach to the real value of this astronomical datum, the more truly we shall be able to assign the amount of the effects which are produced by it.

Not to tarry too long at this part of the subject it will suffice to notice, that on account of the ellipticity of the earth's meridians, the direction of gravity is not towards the centre, and that in the determination of Lunar parallaxes it is necessary to compute the angle, which the normal makes with the diameter drawn to any point on the surface, but this angle being a function of the compression, a knowledge of the figure of the earth becomes here also an indispensable condition.

Enough has perhaps already been said to warrant the conclusion that this is one of the most important problems of astronomy in respect to practical utility, and he who would deny the expediency of prosecuting the researches necessary to its investigation, must be prepared to pronounce the same sentence of exclusion against astronomy as connected with navigation, against geography, against every other branch of science, or else to waive all claim to consistency. But the figure of the earth can only be known by a comparison of measures made in parts of the globe separated from each other by a considerable difference of latitude, such as two large arcs of the meridian or of longitude.

Hence then we arrive at the absolute necessity, as far as science is concerned, of establishing the exact relative value of the units which have been used as standards by the various nations who have engaged in what are called Geodetical operations, and first it is of all things requisite that we should begin by having some decided measure of our own.

For this purpose the Parliament of England selected the yard used by Mr. Bird as the standard, and Captain Kater had the task assigned to him of comparing all the other measures, such as Sir Geo. Shuckburgh's General Roy's, &c. with this; a detail of the experiments made for this purpose will be found in the Philosophical Transactions for 1821, as also the comparison of the English and French standard measures with each other.

The French at the time of the Revolution of 1791, when the rage for fraternizing and levelling was at its height, sought for some means of establishing an universal system of weights and measures which should be common to all nations; but it would obviously be necessary to that end, that some unit, which nature afforded as a constant mark of reference, should be fixed upon as the basis of the system; now nature gives us many lovely flowers and beauteous plants, and a thousand and a thousand diversified shapes, but we can only cull from all her productions two units which are at all accessible and unchanging. These are the lengths of the pendulum in a given latitude, and of the meridional quadrant. The latter of these accordingly was selected, and great pains were taken by the French to deduce the exact distance from the Pole to the Equator by means of the comparison of an Arc extending from Formentera to Dunkirk, with the former measure of 1735, which I have above adverted to as having been undertaken under the government of Louis XV.

The ten millionth part of the meridional quadrant thus found, was taken as the future national standard unit of France, and called the Mètre.

The old French measure was the toise of 6 Paris feet, and the two iron bars of this denomination which went, one to the Polar circle, and the other to the Equator in 1735, had been rigorously compared with each other at the temperature of 13° of Reaumur; one of these, called the toise de l'Academie or toise de Perou, was still in good preservation, but that which went to the North had been rusted in consequence of having been shipwrecked in the gulph of Bothnia.

13° of Reaumur is equivalent to 16¼ of the scale of Celsius, or the centigrade, and to 61°¼ of Fahrenheit. The English standard temperature is 62° of Fahrenheit. The temperature of the mètre, or module, is zero of the centigrade of Reaumur, and 32 of Fahrenheit.

We have still therefore much to abolish before we can arrive at any uniformity of measures, but in the present case it is an object to avoid confounding the subject of measurements made with a view to determine the figure of the earth, with those whose object is the establishing the length of the mètre. The latter seems to be now generally allowed to be a fanciful attempt, for what can it matter, whether we get our standard unit from nature or from art? Whether we first fix our foot or yard, and deduce the quadrant of the meridian in terms of it; or derive the length of our standard from the length of the second's pendulum, or from an aliquot part of the computed quadrant?

But to the determination of the figure of the earth, the relative values of the different national units which were employed, must be accurately known; moreover, as all operations undertaken for the purpose must depend on some base, which has been measured under different states of the thermometer, and perhaps under great alternations of heat and cold, it follows of course that the exact mean temperature must be known and corrected, unless some method can be devised of introducing into our apparatus the principle of its own compensation.

It is not an easy task, however, to ascertain the exact temperature of a rod of metal; thermometers may be placed near it, but they will only give the temperature of the surrounding air, which may differ very sensibly from the metallic bar.

The mode of measurement with a steel chain has hitherto prevailed in England and in India, but it is very objectionable principally on the following accounts.

1st. The impossibility of knowing its exact temperature and the consequent allowance to be made for expansion.

establishing an universal system of weights and measures which should be common to all nations; but it would obviously be necessary to that end, that some unit, which nature afforded as a constant mark of reference, should be fixed upon as the basis of the system; now nature gives us many lovely flowers and beauteous plants, and a thousand and a thousand diversified shapes, but we can only cull from all her productions two units which are at all accessible and unchanging. These are the lengths of the pendulum in a given latitude, and of the meridional quadrant. The latter of these accordingly was selected, and great pains were taken by the French to deduce the exact distance from the Pole to the Equator by means of the comparison of an Arc extending from Formentera to Dunkirk, with the former measure of 1735, which I have above adverted to as having been undertaken under the government of Louis XV.

The ten millionth part of the meridional quadrant thus found, was taken as the future national standard unit of France, and called the Mètre.

The old French measure was the toise of 6 Paris feet, and the two iron bars of this denomination which went, one to the Polar circle, and the other to the Equator in 1735, had been rigorously compared with each other at the temperature of 13° of Reaumur; one of these, called the toise de l'Academie or toise de Perou, was still in good preservation, but that which went to the North had been rusted in consequence of having been shipwrecked in the gulph of Bothnia.

13° of Reaumur is equivalent to 16¼ of the scale of Celsius, or the centigrade, and to 61°¼ of Fahrenheit. The English standard temperature is 62° of Fahrenheit. The temperature of the mètre, or module, is zero of the centigrade of Reaumur, and 32 of Fahrenheit.

through the whole breadth, and leaving 0·3 of an inch of the depth above and below; the parts which remain being perforated so as to admit a conical pivot to work in the two concentrically.

Now, if the two bars be placed parallel to each other and clamped together as abovementioned, and if a flat tongue of iron 0·25 of an inch thick, 1·1 broad, and 6·2 long, with two pairs of pivots, each pair forming an axis projecting perpendicularly to its plane, be applied horizontally to the apertures abovementioned, the distances between the centres of the two axes being 1·8 inch, it is plain that if one bar increase in length more than the other, one extremity of the tongue may, by means of these axes, revolve through a small arc round some point near the other extremity; and moreover, if there be such another tongue and apparatus at each end of the compound bar, both tongues will have a similar tendency, so that if the cause be the same of this increase in length, the one tongue will revolve through an arc just as great as the other.

In Colonel Colby's system, one of the two bars is of brass, the other of iron. The tongue has one axis at 0·5 of an inch from one extremity, working into the aperture of the brass bar, and the other at 2·3 nearly working into that of the iron bar, whilst the rest of the tongue projects outwards.

The expansions of brass and iron are variously stated by different authors, but they are not far from the ratio of three to two.* Let us suppose them to be exactly so, then since 1·8 inch is the distance between the two axes, if double that distance, or 3·6 inch were set off from the centre of the axis, which works in the iron bar on the line produced through both axes, we ought to arrive at a point which would in no wise be affected by the forces arising from the jutting outward or shrinking inwards of the ends of brass and iron bars in consequence of increase of temperature.

---

* Expansion of brass bar, ... ·0000104850 } Hasslar for 1°. of Fahrenheit.
Ditto of iron bar, ... ·0000069844 }

Upon the principles of similar triangles, this point would form the vertex of a set of triangles whose bases are the relative increments of the brass and iron bars from heat, and as there would also be some nodal point on a tongue similarly situated at the other extremity of the compound bar, therefore the distance between these two nodal points would be constant, and in no wise liable to be affected by changes of temperature, provided such increase or diminution of temperature were suffered by each metallic bar at the same time and in equal intensity.

The difficulty then is to mark these neutral points and it is accomplished as follows. Two miscroscopes, with moveable wires, are fixed on solid stone pillars let into a wall of masonry, and when this has had time to dry and become perfectly consolidated, the moveable wires are adjusted over the two dots of an iron, or other standard of ten feet in length, at the temperature of 62° of Fahrenheit.

The bars are then heated in an oven as equably as possible up to the temperature of 180° or upwards, in that state they are taken out and placed under the mural microscopes, and a point on one tongue having been assumed, the corresponding point on the opposite tongue is sought for, which maintains an invariable distance from it during the process of cooling

This operation in slow and tedious like all works of approximation, but it is particularly so because it appears from experiment that the brass and iron bars do not cool equably, if their natural surfaces be exposed to the air. Hence it has been necessary to apply coatings of varnish so as to give surfaces which shall make them radiate alike, and as this varnish must be only applied partially, the quantity, which is just sufficient for the purpose, and no more, must be patiently ascertained by a series of repeated trials.

Strictly speaking, the distances from the neutral points on the tongue to the centres of the two points ought in every position to bear the same proportion to each other as the increments of the brass and iron bars do, but a very little consideration will suffice to shew that the increments of the tongue itself will not be sufficient to answer that condition; the error must however be one of the second order, and has hitherto been considered as rejectaneous, which it most probably is.

The compound bar thus formed, is placed upon two brass rollers which revolve each upon an axis fixed into a deal-box, whose length is sufficient to close the whole metallic apparatus, except the tongue which protrudes at one side, and is protected by a cylindrical cover of brass tube, part of which turns round and brings a circular aperture over the dot marking the neutral point. The box is of deal and painted white on the outside, it is lined with white cloth, and there is an inner box covered on both surfaces with white serge, so that a stratum of air may pass between the outer box and its interior lining.

At each end of this deal box there is a common brass sight which serves to lay the bar approximately; there is also a brass plate with screw holes, by means of which are fixed to the box the arms intended to support the microscopes.

There are seven sets of microscopes, each consisting of two common microscopes, and one telescopic microscope. The use of these is as follows. The two common microscopes are compensated by means of parallel bars of brass and iron in the same manner with the measuring apparatus, and the condition of compensation requires that, when each microscope is in focal distance in respect to the dot of the bar to which it is attached, the horizontal distance between the lines of collimation of the two microscopes shall always be the same quantity, which ought to be six inches of Parliamentary measure at the temperature of 62°

There are six of these compound bars which are aligned in succession by means of an instrument called a boning instrument, placed at a certain number of paces in the rear.

The first operation is to drive a set of pickets into the ground to support the tressels, two of which are required for each bar; this must be accomplished by measurement with a common chain or tape, the line of the pickets being traced with respect to the middle of the bars, and not that of the dots or microscopes.

The pickets being driven, one of the bars having a set of microscopes at each end, is brought into the alignment, by placing the telescopic microscope over the limit of the line to be measured.

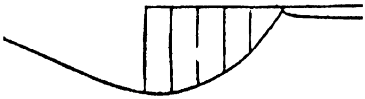
Over the eye tube of this telescopic microscope a small brass upright called a director, is then raised, and the boning instrument, by means of this and the other limit, being now properly placed in alignments, the other end of the first bar is also placed right by means of its director

The second bar is now brought up to the first by placing the rear dot under the advanced microscope attached to the first bar, and raising or lowering it to focal distance. In the same manner the 3rd, 4th, 5th and 6th, when the series is terminated by fixing one of the triangular registers. After the length of the whole six bars has thus been taken off, the leading register is left standing and another set of bars is placed and measured off in the same manner.

For the better preservation of an equable temperature, the whole of the measurement with these bars is carried on under shelter; a certain number of tents of a suitable form being constructed on purpose, and especial care is taken to preserve the apparatus from the direct action of the sun's rays.

The adjustments of the sets of microscopes consist in placing the side telescope parallel to the plane which passes through the lines of collimation of the two microscopes, this is done as follows; direct by means of its sights, the six inch brass ruler to a mark on a piece of paper fixed at thirty or forty feet distance on a wall, and place over it the two microscopes with each of the dots under a wire, then direct the side telescope to the same paper, and mark the point it cuts. Now turn the set of microscopes half round in azimuth, so that the positions may be over the contrary dots to what they were before, and having turned the side telescope half over in altitude, mark the point on the wall which its wire cuts in this new position. If then the distance between each of these points, and the middle point be exactly equal, the line of collimation is quite parallel to the line running through the microscopes, otherwise it must be adjusted half by means of the screws, which affect the axis, and half by those which affect the line of collimation

The measurement of every individual set of bars is taken horizontally, but it does not follow that the surface over which it is conducted need be horizontal; for each tressel stands upon three pickets driven into the ground, and 1st, the heads of these pickets may be left more or less above the surface. 2nd. Upon the pickets a large triangular frame of three inches thick deal is placed, which in cases of emergency may be dispensed with or doubled. 3rd. The tressels may be of different heights, and do actually vary from thirty to six inches; again, each bar is supported upon a brass fabric called a camel which rests upon the tressel, and is furnished with three levelling screws, and one in the middle for elevating, therefore; 4th. The additional height given by the screws is three inches. These four means of adjustment may all be brought into play in descending or ascending a slope; let us suppose the former case: then we should begin with the lowest tressel, with the pickets as near the surface of the ground as possible, perhaps without any triangle over the heads of the pickets, and with the elevating and levelling screws of the camel quite drawn down whilst at the advanced end of the 6th bar, we should leave one inch or more of the pickets exposed, the highest tressel, supported on perhaps two triangles, would be used, and the elevating and levelling screws would be drawn out to their full extent.



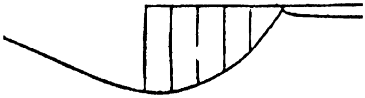
The extreme difference of height which might thus be produced, would be about thirty inches in a set (or sixty-three feet,) but in this as in all other cases of human life, it is desirable to avoid having recurrence to extremes, and the medio tutissimus is the best guide

I have said that each end of the frame of the bar rests on a brass support called a camel. These have rollers at top so that the motion of the whole longitudinally is easily effected with the hand, but that one of each pair of camels which supports the rear end of the bar, has a brass plate appended to it with a steel screw, whereby after the dot has, as nearly as can be, been brought into its proper position under the microscope, any small alteration may be given to it longitudinally. This will be seen by a reference to the apparatus where the plate being fixed to the box by two brass screws, the long steel screws I have above mentioned, act in the same manner as a tangent screw on the limb of an instrument, and draw the whole bodily forward or thrust it backwards in a direction parallel to itself. There is also to each camel a large milled headed brass screw, which gives a differential motion laterally to each end of the bar.

The registers which mark the limits of each set of bars in succession consist of a frame of cast iron, of a pyramidal shape, surmounted by a brass plate with a circular aperture of two inches in diameter. Through this aperture a tube is adapted to slide up and down, at the top of which is a circular head hollow, and perforated in the middle, so that an internal plate on which four screws act at right angles to each other may be moved differentially in a lateral or longitudinal direction; this moveable plate carries a very fine dot engraved on silver: some of these registers have the tube made to slide below the frame altogether, in which case the ground must be excavated from beneath it. Some are a mere triangular slab of cast iron with a moveable brass register in the middle, they are used at leaving off at night, and in cases where they are likely to be left standing for any time, being less liable to derangement than the more lofty ones. Each register rests upon a slab of stone sunk into the ground for the purpose.

The meaning of the sliding tubes is that the small dot on the moveable plate may be kept as nearly at the same distance from the telescopic micrometer as practicable, but in cases of ground which slopes greatly and always where this is not attainable, a provision is made for altering the focal length of this microscope by changing the object glass. A small box which accompanies contains twelve sets of object glasses for this particular purpose, varying from four to twelve inches, and there are four others which are adapted to a difference of height so great as twenty feet.

ground, and 1st, the heads of these pickets may be left more or less above the surface. 2nd. Upon the pickets a large triangular frame of three inches thick deal is placed, which in cases of emergency may be dispensed with or doubled. 3rd. The tressels may be of different heights, and do actually vary from thirty to six inches; again, each bar is supported upon a brass fabric called a camel which rests upon the tressel, and is furnished with three levelling screws, and one in the middle for elevating, therefore; 4th. The additional height given by the screws is three inches. These four means of adjustment may all be brought into play in descending or ascending a slope; let us suppose the former case: then we should begin with the lowest tressel, with the pickets as near the surface of the ground as possible, perhaps without any triangle over the heads of the pickets, and with the elevating and levelling screws of the camel quite drawn down whilst at the advanced end of the 6th bar, we should leave one inch or more of the pickets exposed, the highest tressel, supported on perhaps two triangles, would be used, and the elevating and levelling screws would be drawn out to their full extent.



The extreme difference of height which might thus be produced, would be about thirty inches in a set (or sixty-three feet,) but in this as in all other cases of human life, it is desirable to avoid having recurrence to extremes, and the medio tutissimus is the best guide

I have said that each end of the frame of the bar rests on a brass support called a camel. These have rollers at top so that the motion of the whole longitudinally is easily effected with the hand, but that one of each pair of camels which supports the rear end of the bar, has a brass plate appended to it with a steel screw, whereby after the dot has, as nearly as can be, been brought into its proper position under the microscope, any having been lent for the occasion by the Chairman, and it is of importance to remark, that two of the Gentlemen of the Royal Engineers who had taken a prominent part in the measurement at Loch Foyle, Lieutenants DRUMMOND and MURPHY, were with me for two days, in order that no important step of the operation might be overlooked.

Having measured the nine sets of bars in question, I returned over the same ground, and on reaching the register from which I had originally started, the return measurement exceeded the prior one by $\frac{1}{40}$th of an inch. Now $\frac{1}{40}$th of an inch in five hundred and sixty-seven feet, would amount to 5·6 inches in eight miles, and to one hundred and forty-five inches in a section of the meridian of about three degrees.

The increments of degrees between the latitudes of 8° and 31° vary from 5·2 to 16·6 fathoms; if therefore we could be certain that this were the greatest quantity to be feared, there could be no doubt, philosophically considered, that the compensation bars would be quite adequate to the purpose for which they were designed, and that the superior accuracy attainable from them, would be commensurate with the greater toil entailed by their use, and the increased expence and complexity of their structure.

It is my opinion that the variation of $\frac{1}{40}$th of an inch is rather more than need be apprehended, because the formation of Lords' Cricket Ground is a thick clay, which retains the moisture at the surface, and as for several days of the operation rain descended in great quantities, there was an alternation of dryness and humidity much more unfavourable than need be looked for in actual measurement on a great scale.

In fact the constant trampling of the feet of the soldiers and others who were occupied in the work, rendered such parts as were hollow perfect swamps, and ancle deep in mud and water, whilst the more elevated parts were hard and dry.

This is a matter of opinion in which every person must judge for himself; but if we refer to the bases measured by Maire and Boscovich in Italy, by Delambre and Mechain in France, by Bouguer and De la Condamine in Peru,* by Roy and Mudge in England, by my predecessor and myself in India, we shall find no very insecure test of comparison to direct our judgment in forming an estimate of the superior accuracy likely to be attained by the new apparatus. I select these instances because I am not aware of any other operations in which two bases, verificatory of each other, have been measured. To take these then in order of their dates.

The first base was measured in the plain of Yarouqui from Carabouron to Oyambaro. It was performed with wooden rods called perches, prepared on the spot from a comparison with the iron toise. It was commenced on the 3d October, and ended on the 3d November, 1736. The ground was gone over by two parties independent of each other, and the mean of the two results was 6272.6559 toises = 7.60 miles in a horizontal direction. The base of Tarqui, which is in 3° 4′ South of the Equator, was measured in the same manner in the month of August, 1739: it was carried on through swampy ground, and the wooden rods floated on the stagnant water, ("nous fûmes dispensès dans ce trajet de faire usage du niveau, les perches avec les quelles nous opérions flottaient sur l'eau.")

This base, reduced to the level of Carabouron, was 5258,949 toises, equal to 6·37 miles, and the same distance computed from the series of triangles was found to be 5260.03 toises,† shewing a variation of 1·081 toise between actual measurement and computation; but a length of 1·081 in 5260.03 amounts to 13 inches in a mile, or 104 inches in 8 miles, and nearly 38 fathoms in a section of 3 degrees. In the month of April, 1751, MM. MAIRE and BOSCOVICH, under the auspices and at the charge of Pope BENEDICT XIV, commenced the measurement of a base line from the tomb of CECILIA METELLA to within 3 miles of Alba. The operation was executed with wooden rods set off from the Roman palm, and was found to be 7901.14 passi Romanì, equal to 7.312 English miles: the base of verification for this was measured at Rimini, and found to be 8034.67 passi, equal to 7.436 miles, whereas the latter deduced from the former in the table of triangles (Liv. II. Art. 20,) is only 8033·4, differing 1.27 passo, or 10 inches in a mile.

---

* The *Conquestadore* of 64 guns, and the *Incendio* of 50 guns, sailed from Cadiz Bay, May 26th, 1735. Bouguer, Godin, and De la Condamine, sailed from la Rochelle, in a Royal vessel 16th May 1735.

24th November embarked at Portabello, in company with the Spanish gentlemen; on the 10th June 1736, all the party assembled at Quito.

Dans un des intervalles de ce travail nous observames, le 19th Septembre au soir, l'Eclipse de la Lune. Tandis qu'on prepar it lesaperches que devaient nous servir à méaurer la base.

† 5260 toises = 6 miles 3 furlongs.

The length of the base of Perpignan is 6006.25 toises, it was commenced by MECHAIN and finished by DELAMBRE, in the month of Germinal, year 6 of the Republic, with the platina bars. It was connected with that of MELUN, which was executed by DELAMBRE, and is 6075,9 toises, the former deduced from the latter is 6006·09, exhibiting a difference of 0·16 of a toise, which is about 0.17 of an inch in a mile. The latter was completed in thirty-eight days: the expressions of the author are—"en travaillant depuis neuf heures du matin jusqu'au coucher du soleil nous n' avons jamais pus parvenir à mesurer plus de 360 mêtres* en un jour, c'est à dire, à placer plus de quatre vingt dix régles au bout l'une de l'autre." The base of Perpignan occupied in all 48 days, and was terminated on the 1st supplemental day of the year 6. The author says in regard to this—"on voit donc que dans les circonstances les plus favorables ou ne peut guère se flatter avec tous les soins et le scrupule que nous y apportions de mésurer une base de †12000 mêtres en moins de cinquante jours."

---

* 1181·1237 English feet.

† 39370.79 feet, or 7½ miles nearly, which is at the rate of 797 or 800 feet per day.

This is a matter of opinion in which every person must judge for himself; but if we refer to the bases measured by Maire and Boscovich in Italy, by Delambre and Mechain in France, by Bouguer and De la Condamine in Peru,[*] by Roy and Mudge in England, by my predecessor and myself in India, we shall find no very insecure test of comparison to direct our judgment in forming an estimate of the superior accuracy likely to be attained by the new apparatus. I select these instances because I am not aware of any other operations in which two bases, verificatory of each other, have been measured. To take these then in order of their dates.

The first base was measured in the plain of Yarouqui from Carabouron to Oyambaro. It was performed with wooden rods called perches, prepared on the spot from a comparison with the iron toise. It was commenced on the 3d October, and ended on the 3d November, 1736. The ground was gone over by two parties independent of each other, and the mean of the two results was 6272.6559 toises = 7.60 miles in a horizontal direction. The base of Tarqui, which is in 3° 4′ South of the Equator, was measured in the same manner in the month of August, 1739: it was carried on through swampy ground, and the wooden rods floated on the stagnant water, ("nous fûmes dispensès dans ce trajet de faire usage du niveau, les perches avec les quelles nous opérions flottaient sur l'eau.")

This base, reduced to the level of Carabouron, was 5258,949 toises, equal to 6·37 miles, and the same distance computed from the series of triangles was found to be 5260.03 toises,[†] shewing a variation of 1·081 toise

---

[*] The *Conquestadore* of 64 guns, and the *Incendio* of 50 guns, sailed from Cadiz Bay, May 26th, 1735. Bouguer, Godin, and De la Condamine, sailed from la Rochelle, in a Royal vessel 16th May 1735.

24th November embarked at Portabello, in company with the Spanish gentlemen; on the 10th June 1736, all the party assembled at Quito.

Dans un des intervalles de ce travail nous observames, le 19th Septembre au soir, l'Eclipse de la Lune. Tandis qu'on prepar it lesaperches que devaient nous servir à mésurer la base.

[†] 5260 toises = 6 miles 3 furlongs.

The base of Romney Marsh was measured with the steel chain, supported on coffers, it was begun on the 15th October, 1787, and ended 4th December, and was 28535.677 feet, and here we find introduced two of those cases of perplexity which I have alluded to before: viz.

Correction for contraction of the chain, ...	Sub. 1.0667 feet.
Correction for wear of the chain, ...	Add. 0.2735

I do not mean to say these are incorrect—all I mean is, that they are hypothetical, and as such are not as satisfactory to the common sense and good understanding of mankind as a measurement which is dependent on fact alone.

This base when deduced from that on Hounslow Heath by the triangulation, was 28533.3 feet, so that there is a difference between computation and actual measurement of 2.277 feet, which is at the rate of 5.06 inches in a mile.

In the Summer of 1791, the base on Hounslow Heath was re-measured with the steel chain in coffers, supported on pickets. The operation occupied 43 days, and was found after all reductions, to be 27404.3155 feet, or about .3018 of a foot greater than the former one—this is about .607 of an inch per mile, and the daily progress was 638 feet.

It is not necessary to go into a detail of all that has been executed with the steel chain in Great Britain, but it is some criterion for us to form a judgment respecting that apparatus, when a gentleman of Colonel Colby's reputation and talent, who has been so active a participator in all connected with its application, comes forward as an active reformer, and by introducing the apparatus of which you now see the fac-simile, virtually pronounces his opinion as to the fallibility of that which he seeks to supercede.

As to the operations by my predecessor, they are all before you in the memoirs of this Society, excepting the last two bases, of which a detailed account is found in my printed book.

The first of these is the base of *Takal Khéra*, which was measured by Colonel **Lambton** on the ground, between the 6th January and 25th January, 1822. It was 37912.56, &c. feet, and consequently the daily progress was 1896 feet nearly.

The base of *Seronj* was measured by me on coffers, and was 38411.9 feet, it was completed in 20 days, i. e. between 24th November and 13th December, 1824, the daily rate of progress was therefore 1920 feet.

The base of *Seronj* computed from the triangulation between it and *Takal Khéra* is 38412.16 feet, giving a difference of 0.26 feet in the whole length, or .4288 of an inch in a mile.

The *Beder* base, as will be seen on reference to the Transactions of this Society, was found from measurement to be 30806.176 feet, but the same base deduced from the series of triangles connecting it with *Takal Khera*, is only 30799.61, giving a difference of 6.57 feet nearly, or 13.516 inches per mile.

Thus then, it would seem, that the chain though generally correct, is not of that trust-worthy nature that can induce an entire confidence in the results it produces. A happy combination of errors may perhaps, and generally will make them annihilate each other, but there is an uncertainty attached to the reliance on such a contingency, which is any thing but satisfactory in cases where the exact sciences are concerned.

XIII.

EXPERIMENTS
ON THE
STRENGTH AND ELASTICITY
OF
INDIAN WOODS.

BY CAPTAIN H. C. BAKER.
Bengal Artillery,
AGENT FOR IRON SUSPENSION BRIDGES, &c.

THE experiments detailed in the following Table were made on different occasions, to determine the strength of various specimens of Wood supplied to me by the Honorable Company's Timber Agents, and by private individuals, who were interested in the subject, and who had opportunities of obtaining foreign Woods in their visits to the Tennasserim Coast, Arracan—the Morung forests, Orissa, &c. A short account of some of my original experiments, was published in the *Gleanings in Science,* vol. I, pages 123 and 231; but as many of the Woods then submitted to trial, were hardly in a seasoned state, I have included in the present Table only the later experiments upon them when they were perfectly seasoned, and when therefore more dependence could be placed on the results.

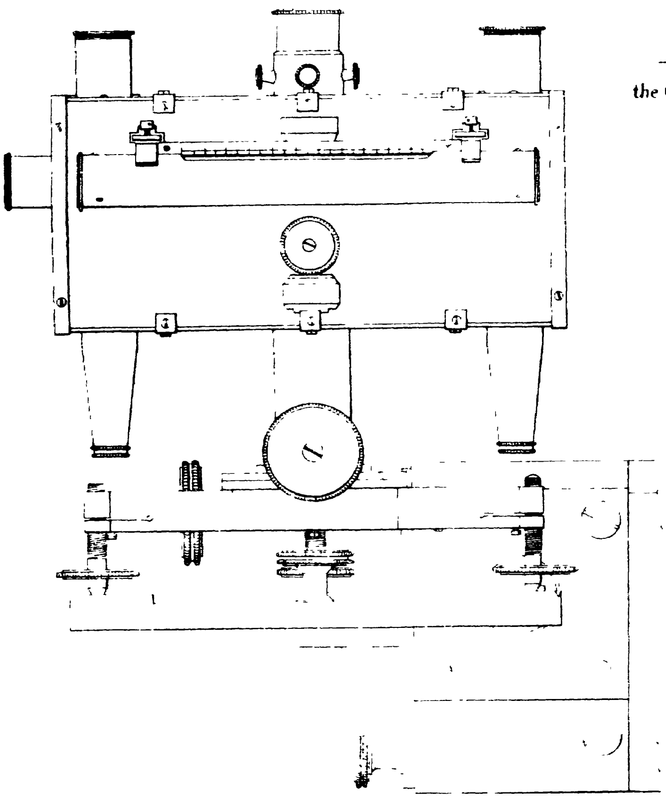
I regret that the Notes furnished with the Specimens were, in most cases, insufficient to enable me to describe at large the qualities of the several kinds of Timber, or the purposes to which they are applied in the countries where they flourish: the native names too, are, in many instances, of doubtful orthography, resting upon the vague pronunciation of the people of the spot, and taken down by mere sound of ear. In most instances, however, with the kind assistance of the Revd. Dr. CAREY, and Mr. POTTER, for the Woods of Bengal and the East, and of Drs. ROYLE and FALCONER, for those of Upper India, I have been able to assign the Botanical names of the trees.

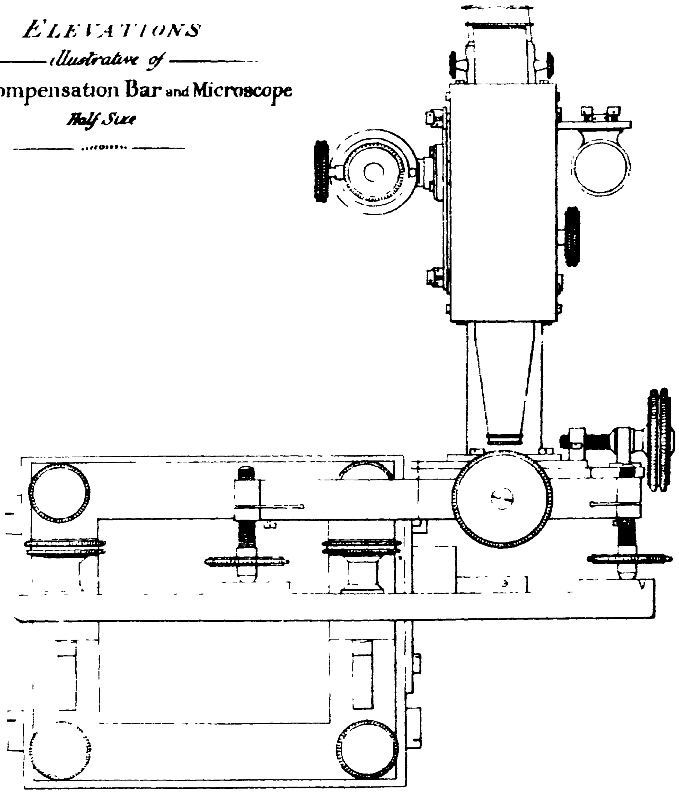
The numbers in the first column refer to the Specimens lodged with the Society. The results given are the means of about four experiments on each kind of wood. The term C, or direct cohesive strength in lbs. avoirdupois in the square inch, in the last column, is experimentally found by tearing asunder about an equal number of specimens, turned according to the method described in BARLOW's Treatise on the "Strength and Stress of Materials."

The Specimens, except when otherwise stated, were six feet long, two inches square: the distance of the supports five and a half feet.

CALCUTTA,
November 1, 1832.

ELEVATIONS
illustrative of
the Compensation Bar and Microscope
Half Size





J B Tann lith

Mean results of a course of Experiments on the elasticity, and on the transverse and direct cohesive strength of various Indian Woods, 1830.

Corresponding Number of Box Specimen.	NAME.		Specific Gravity.	Greatest weight and deflection whilst elasticity remained.		Breaking weight in lbs.	Ultimate deflection in inches.	MEAN VALUES OF				REMARKS.
	LOCAL.	BOTANICAL.		Weight, lbs.	Deflection, inches.			U from the formula $U = \frac{l^2}{d\Delta}$	E from the formula $E = \frac{l^3 W'}{ad^3\delta}$	S from the formula $S = \frac{lW}{4ad^2}$	C Direct cohesive strength in lbs. per sq. inch.	
37	Pussoor, ...	Xylocarpus granatum, ...	837	150	698	478	2·64	981	5004220	1075	6588	Soondurbuns 1829.
37	Ditto, ...	Ditto, ...	632	200	·869	705	3·7	700	5368929	1586	6588	
38	Chittagaon Oak,	Quercus castanicarpa ? ...	962	500	1·13	1168	4·0	648	10322120	2628	23944	Soondurbuns, received 1828-9, from Captain Murray, Executive Officer, Public Works at Burisal, seasoned.
41	Chumalis, ...	Artocarpus chaplasha, ...	581	200	1·085	575	3 3	785	4241910	1294	10429	
43	Choangree.		562	200	·971	616	3·36	771	4743900	1386	8470	
42	Hurina, ...	Acacia heterophylla ?......	994	500	1·6	1352	4 7	551	7290000	3042	32472	
39	Gulgulia, ...	Amyris agallocha, ...	714	200	·86	566	3·0	864	5425116	1273	9219	
40	Telsur, ...	Shorca talura ?...........	769	300	1·0	947	5·2	490	6998400	2131	10994	
44	Koorye, ...	Acacia marginata, ...	839	300	·981	778	3·4	760	7133944	1750	12506	
47	Sassafras, ...	Crytocarya glaucescens ? ..	557	200	·91	626	4·1	630	5127032	1658	10778	Tenasserim Coast, imported 1827-28, by the *Ernaad*, well seasoned.
46	Red or dye wood, Mergui, ...	Melanorrhoea usitata, ...	823	450	1·3	993	3·4	760	8075076	2234	18562	
54	Pyeng-ma, ...	Lagerstrœmia, ...	734	350	1·12	1015	4·9	530	7284410	2284	22513	
55	Kanza kurro, ..	Meliacea, ...	703	350	1·0	918	3·5	740	8164800	2065	13096	
57	Anaun, ...		1048	300	·768	932	2·95	878	9112500	2097	14008	
52	Thengan, ...	Hopea odorata, ...	707	300	·993	932	4·0	648	7047734	2097	12770	
56	Kaddoot, ...		751	350	1·0	985	3·8	680	8164800	2216	15986	
53	Thaban, ...		772	450	1·22	1034	4·7	550	8604590	2326	19588	
41	Chumaleez, ...	Artocarpus chaplasha, ...	499	150	·806	443	2·5	1039	4341439	997	7447	Chittagaon, 1830.
245	Much, ...	Pterospermum acerifolium,	672	300	1·0	876	5·7	450	6998400	1971	18818	
238	Lobanae pooya, .		506	150	·73	478	2·5	1037	4793424	1075	9684	
248	Badna	Quercus castanicarpa, ...	1028	500	1·16	1064	5·2	490	10065170	2489	20819	

Corresponding Number of Box Specimen.	NAME.		Specific Gravity.	Greatest weight and deflection whilst elasticity remained.		Breaking weight in lbs.	Ultimate deflection in inches.	MEAN VALUES OF				REMARKS.
	LOCAL.	BOTANICAL.		Weight, lbs.	Deflection, inches.			U from the formula $U=\frac{l^2}{d\Delta}$	E from the formula $E=\frac{l^3W'}{ad^3\delta}$	S from the formula $S=\frac{lW}{4ad^2}$	C Direct cohesive strength in lbs. per sq inch.	
242	Chugarasee, ...	Swietenia chuckrassa, ...	859	150	·718	466	2·7	960	4873546	1048	7784	Chittagong, 1830.
239	Peetras, or Pitraz		665	200	69	643	3 5	740	6861176	1447	9246	
241	Chudool, ...	Hybiscus’	351	100	31	339	3·5	740	2880000	763	4488	
232	Dood Peechul, ..	Trewia nudiflora, ...	522	150	·706	505	3·2	810	4956373	1136	9079	
231	Hureetukee, ...	Terminalia chebula, ...	840	200	·9	766	4·8	540	5184000	1723	14476	
240	Goodgootea, ...	Amyris agallocha, ...	862	200	·825	761	4·5	576	5655272	1712	13038	
235	Hureena Aswara,	Acacia heterophylla, ...	1035	200	·86	602	3·1	836	5425116	1354	12582	
237	Loo-eea, ...		671	150	·618	540	3·15	820	5719983	1215	13588	
243	Kamdeb, ...		615	200	·86	685	4·6	560	5425116	1766	8134	
233	Gurjun, ...	Dipterocarpus incanus, ...	853	300	·8875	897	4 95	523	7998171	2018	......	
236	Jam,...	Calyptranthes jambulana, ...	825	200	·925	637	4·3	602	5043889	1433	12440	
244	Koorye, ...	Mimosa marginata, ...	963	200	1·025	522	3 75	708	6292217	1553	11795	
234	Oreeam, ...	Mangifera sylvatica, ...	639	150	·631	632	3 7	700	6337700	1625	7550	
247	Amrooz, ...	Pyrus communis, ...	564	150	1·14	471	4 6	560	3069473	1059	8118	
249	Babul, ...		416	100	·65	434	4 7	550	3588923	976	6087	
84	Paunjur, ...		994	500	1·175	1209	4 6	560	9926808	2720	16778	Morung forests, 1828.
88	Dhauba, ...		949	500	1 194	1259	3 75	691	9768844	2833	22413	
79	Koossum, ...	Carthamus tinctorius’	1107	450	1 875	932	2·9	890	5598720	2097	12094	
83	Assaun, or Asin,	Pentaptera tomentosa, ...	862	450	1 194	1037	4 95	523	8791959	2333	21919	
80	Kussooma, ...		949	300	1·05	745	3 65	710	6605619	1676	13919	
85	Jummooa, ...	Sizygum lateriflorum.	948	300	1·064	831	4 175	620	6397074	1872	11467	
87	Kurmine, Kurmah, ...	Phœnix dactylifera, ...	655	200	·781	706	3·6	720	6053905	1588	14941	
81	Paunder, ...	Sp. of Bignonia, ...	721	200	·7	985	5·575	450	6665142	2216	13022	

86	Seriss, ...	Acacia Serisha, ...	792	300	·969	926	·36	720	7222291	2083	9582	Morung forests, 1828.
89	Bhaunjee,.....		797	200	·71	766	3·6	720	6571267	1723	12142	
82	Dhoree,........	Grislea-tomentosa, ...	713	200	·65	661	2·7	680	7177846	1487	12882	
90	Tekolee, ...		793	300	1·025	989	5·075	510	6827707	2225	18005	
206	Abnoos, ...	Diospyros melanoxylon, .	893	300	·85	741	4·0	648	8233417	1667	12593	Orissa, 1830. felled 1829.
65	Sissoo, ...	Dalbergia sisu, ...	1032	450	1·325	1133	5·25	494	7922716	2548	18500	
253	Mahole,........	Bauhinia racemosa, ...	1002	150	·56	619	3·8	680	6248571	1397	14437	Dhekanal, forest Orissa, felled 1829.
258	Assun, ...	Pentaptera tomentosa, ...	1009	300	1·06	909	4·8	540	6602264	2045	22423	
259	Teneea,.......		1047	300	·9	840	3·275	790	7776000	1890	12026	
256	Cussee,......		1040	200	·775	702	3·9	660	6020129	1579	11158	
254	Nember, ...		965	150	·75	478	2·975	680	4665600	1075	9683	
255	Tentara, ...		850	200	·7125	687	2·675	960	6548210	1546	15501	
252	Cungra,.......	Webera corymbosa, ...	947	200	·725	702	2·75	942	6435310	1579	15718	
250	Saul, ...	Shorea robusta, ...	894	450	1·2	1018	4·3	602	8748000	2290	16351	
263	Mussoo, ...		884	450	1·66	1014	9·25	280	6323855	2281	20558	
264	Rajmooee, ...		825	200	·8875	658	3·875	660	5257014	1480	9804	
64	Peersaul, ...	Buchanania latifolia, ...	795	300	1·875	916	4·4	580	3732480	2061	12906	
260	Bundun, ...		855	300	·925	952	4·8	660	7565837	2142	23504	
257	Patmooee, ...	Trewia nudiflora, ...	732	200	·76	726	3·525	900	6138947	1636		
261	Croom, ...	Phœnix dactylifera, ...	730	300	1·2125	799	4·7	680	5771871	1798	17231	This is the "Kurma" of Tirhoot, Kurmine of Nathpore.
267	Koochila, ...	Strychnos nux vomica, ...	971	200	·75	702	3·45	720	6220800	1579	13627	
265	Sujna puttrea,.		925	200	·725	629	2·65	981	6435310	1415	11000	
262	Teak,.	Tectona grandis, ...	729	200	·7	643	2·35	1103	6665142	1447	21957	
91	Gamar.	Gmelina Arborea, ...	645	150	·69	609	3·9	820	5071304	1370	11181	
	Patmooee, ...	Trewia nudiflora, ...	459	100	·55	458	3·85	830	4241454	1630	5434	
251	Mahaneem, ...	Qu. Melia semper virens?	430	100	·55	396	2·75	942	4241454	891	5189	
268	Benta.	Ricinus communis, ...	899	200	·725	897	3·85	830	6435310	2018	9763	
207	Mahogany, ...	Swietenia mahogani, ...	673	200	·90	786	4·76	670	5184000	1768	11185...	Honduras.
73 A	Satin wood, ...	" chloroxylon, ...	1020	300	1·01	1068	5·25	600	6029108	2403	10866	Purchased in Calcutta, supposed from Dukhan
269	Koossum, ...	Carthamus tinctorius, ...	930	450	·8375	1227	2·65	821	6458860	2531	11612	Dhekanal forest, Orissa, 1829 Received 1830
266	Bheroo, ...	Zizyphus jujuba, ...	846	500	1·17	1176	3·5	740	9969230	2646	13016	
271	Peetara, ...	Trewia nudiflora, ...	528	200	·975	518	3·975	800	4785230	1165	10970...	Arracan Received 1830, June.

Corresponding Number of Box Specimen.	NAME		Specific Gravity.	Greatest weight and deflection whilst elasticity remained.		Breaking weight in lbs.	Ultimate deflection inches.	MEAN VALUES OF				REMARKS.
	LOCAL.	BOTANICAL.		Weight, lbs.	Deflection, inches.			U from the formula $U=\frac{l^2}{d\Delta}$	E from the formula $E=\frac{l^3W'}{ad^3\delta}$	S from the formula $S=\frac{lW}{4ad^2}$	C Direct cohesive strength in lbs per sq. inch.	
229	Burroona,......	Capparis-trifoliata, ...	414	150	·8125	493	3·9	820	4065600	1109	10761	Arracan. Received 1830, June.
273	Kuddumba, ...	Nauclea cadumba, ...	403	150	·8625	489	4·025	790	3782918	1100	7999	
272	Chasteen, ...	Alstonia ?	448	150	·725	420	2·4	1080	4826482	945	4668	
226	Jumoorcea, ...		796	200	·79	831	5·45	587	5813831	1870	18769	
210	Basualeea,......	Lagerstrœmia grandiflora,..	471	100	·65	412	3·25	980	3588923	927	7824	
228	Sunnusuleea, .	Symuplocos spicata ?	431	100	·5625	452	3·425	930	4147200	1017	9285	
196	Gouda-aswara,..	Vitex ?	726	150	·65	761	3·9	820	5383384	1712	19182	
274	Chakhoa, ...	Cassia obtusifolia, ...	376	100	·81	398	5·6	571	2880000	895	5298	
200	Kesuma,..		721	200	·84	778	5·8	551	5554285	1750	19922	
227	Brenjooree, ...	Cassia Sumatrana,.......	629	150	·99	479	3·45	927	3534545	1078	12496	
230	Bhadee,........	Garuga pinnata,..........	529	100	·76	410	4·15	771	3069473	922	6476	

Note.—It has been thought better to leave the names as written in the manuscript, since, in many cases, the orthography according to the system followed in the Researches could not be introduced, for want of reference to the names in the native character. P.

XIV.

DESCRIPTION

OF THE

WILD DOG OF THE HIMALAYA.

By B. H. HODGSON, Esq.

KATHMANDU.

CANIS PRIMÆVUS. (Mihi.)

The *Búánsú* of the Nipalese. *Habitat,* The whole of the Sub-Himálayan ranges from the Satlej on the West to the Brahmapútr on the East.

SPECIFIC CHARACTER.

Wild Dog, with six molars only in the lower jaw, double coat, hairy-soled feet, large erect ears, and very bushy straight tail, of medial length, deep rusty colour above, yellowish below.

THE Dog, man's first and best ally among the brutes, cleaving to us from the beginning, accompanying us in all our settlements in every climate of the habitable globe, and submitting his fine plastic form and faculties to be moulded at will by our wants and our caprices, has been so thoroughly changed by influences very similar to those which have operated upon ourselves, that his original, like our's, has been supposed to have now become inscrutable.

The Greyhound and the Bull Dog, like the Georgian and the Negro, are, it is supposed, in their respective kinds, specifically the same; and the test of this specific identity is that the progeny is prolific. But the application of this test to the Canine race having been found to identify the Wolf, the Jackal, and the Fox, with the Dog, the Zoologists of the last age, who unhesitatingly admitted the test, and who had no knowledge of a Wild Dog, properly so called, assumed, of necessity, some of them, the Wolf, others, the Jackal, and others again, the Fox, as the primæval type of the Canine race. The superior Zoological Science of the present age has perchance suggested some little doubts as to the soundness of the test of species above named; and, certainly, if we pursue this hypothesis into all its known consequences, we shall see room for hesitation. Although, therefore, anatomical investigation has failed to discover any material difference of organization or habit between the Wolf, Jackal, Fox and Dog, and although these several races will breed together, yet the present masters of the subject of Canine genealogy (M. F. CUVIER and M. DESMAREST) notwithstanding their continued want of an unquestionable Wild Dog, have refused to supply the deficiency of an original type by adopting as such the Wolf, the Jackal, or the Fox.

By M. F. CUVIER whose arrangement of the CANINÆ, has been ratified by all the first Zoologists in Europe,—the Dogs. are disposed according to their approximation to the primitive type so far as that type was discoverable in the wildest race known then to exist, and of which there were specimens accessible to him. The race in question is the *Dingo* of Australia.

But, as the *Dingo* is, unquestionably, at least half reclaimed, I presume that a careful account of an entirely wild species of Dog, will be very acceptable to all who take an interest in the subject And which of us but must regard with interest the portrait of the primitive Dog, either from affection for that devoted friend and follower of human kind, or, from the light which the inquiry is calculated to throw upon the nature and limits of the distinction of species.

The *Búánsú*, or Wild Dog of the *Nipalese*, inhabits that part of these mountains which is equidistant from the snows and the plains, or in other words the middle region of *Nepal*. But he frequently wanders into the southern division, and, sometimes, into the northern. His limits, east and west, are, as I know, the *Kali* and *Tista;* and, as I am informed upon good authority, the *Satlej* and the *Brahmapútr*. Wild Dogs, probably not materially differing from those of *Nepal*, are found, likewise, in the *Vindhya*, the *Ghâts*, the *Nílgiris*, the *Kasya Hills*, and finally, in the chain extending brokenly, from *Mirzapur*, through south *Behar* and *Orissa* to the *Coromandel Coast*.

Nor do *Ceylon* and the Eastern Islands want their Wild Dogs; and it is not therefore without surprise that I find the first Zoologists in Europe, whilst expressly treating of the Dog, as he was prior to all cultivation, instancing the more than half domesticated races of Australia and of North America. But the fact is that the Wild Dog of the East (where alone he seems now to exist) is so extremely wild as to be really seen, more rarely killed, and still seldomer procured alive; and that Britons in India have too little leisure to record with the requisite accuracy of detail for scientific purposes their casual observations, whilst sporting, of new and remarkable animals. I have myself been acquainted with the existence and general character of the Wild Dog of *Nepal*, for a long time past, and some years ago I sent to M. DUVAUCEL, two very fine specimens alive; which, however, probably met the fate too often attending presents of this sort.

But having since obtained many individuals, alive, some of which lived in confinement many months and even produced young, having been enceinte when they reached me, I considered it my duty to keep memorandums of such traits of character and manners as I was enabled to observe; and, as I see no prospect of the task falling into abler hands, I shall now record the substance of those memorandums, embodying them in such a description of the essential characters, aspect and habits of this most rare animal, as my small conversancy with the science will permit me to give.

To my description, I shall add drawings of the *Búánsú* and of his skull, together with (for the sake of comparison), others of the Jackal and Fox, and of their skulls. These drawings are upon an uniform scale, reduced with the Camera, from others of the natural size; and, in order to be more precise, I shall in my description of the *Búánsú* follow the principle upon which the sketches have been executed; that is, I shall endeavour to illustrate my subject by constant reference to the Jackal, and occasional reference to the Fox—animals which are, or ought to be, sufficiently well known.

Of all the wild animals that I know of similar size and habits, the *Búánsú*, which is large, gregarious, and noisy in his huntings, is the most difficult to be met with. He tenants solely the deepest and most solitary forests of this woody and little peopled region. The woods which cover the mountains environing the valley of *Nepal* proper afford shelter to numbers of Jackals as of other wild animals; but the *Búánsú* never was known to enter them, or, to approach so near to a populous district. This prototype of the most familiar of all quadrupeds with man is, in the perfectly wild state, the most shy of his society. I never beheld the *Búánsú* myself in the state of freedom, and therefore what I am about to say of his manners in that state must rest upon the authority of others—highly respectable natives who spoke to what they personally knew.

The Wild Dog preys by night and by day, but chiefly by day. Six, eight, or ten unite to hunt down their victim, maintaining the chase by their powers of smell rather than by the eye. They usually overcome their quarry by dint of force and perseverance, though they sometimes effect their object by mixing stratagem with direct violence. Their urine is peculiarly acrid: and they are said to sprinkle it over the low bushes amongst which their destined victim will probably move; and then, in secret, to watch the result. If the stratagem succeed they rush out upon the devoted animal, whilst half blinded by the urine, and destroyed it before it has recovered that clearness of vision which could best have enabled it to flee or defend itself.

This trick the *Búánsús* usually play off upon the animals whose speed or strength might otherwise fail them, such as the buffaloe, wild and tame, and certain large deer and antelopes. Other animals they fairly hunt down, or furiously assail and kill by mere violence. In hunting they bark like hounds; but their barking is in such a voice as no language can xpress. It is utterly unlike the fine voice of our cultivated breeds; and almost as unlike to the peculiar strains of the jackal and of the fox. The *Búánsú* does not burrow like the wolf and fox : but reposes and breeds in the recesses, and natural cavities of rocks, in the manner of the jackal of *Nepal*. These peculiarities of domicile are probably in a great degree the consequenceso fthe respective habitats of the animals in open plains or mountain fastnesses: and they doubtless change them when constrained to change their location. There is scarcely a wild animal, however large or formidable which the Wild Dogs will not sometimes attack and destroy; and tame buffaloes and cows, when grazing in very solitary districts, sometimes fall a sacrifice to their ravenous appetite. Human beings they are never known to attack; and indeed they seem to be actuated by a very peculiar degree of dread of man. Those which I kept in confinement when their den was approached rushed into the remotest corner of it, huddled one upon another with their heads concealed as much as possible. I never dared to lay hands on them, but if poked with a stick they would retreat from it as long as they could, and then crush themselves into a corner, growling low, and sometimes, but rarely, seizing the stick and biting it with vehemence. After ten months'confinement, they were as wild and shy as the first hour I got them. Their eyes emitted a strong light in the dark; and their bodies had the peculiar fœtid odour of the Fox and Jackal in all its rankness. They were very silent, never uttering an audible sound save when fed, at which time they would snarl in a subdued tone at each other, but never fight: nor did they on any occasion show any signs of quarrelsomeness or pugnacity,—I turned a female jackal amongst them, which they admitted to share their den without the least sign of dissatisfaction. She lived amongst them many months, but never showed any symptoms of breeding; nor indeed did any of the Dogs amongst themselves, though there were males and females. Three of the latter, at different times, came to me enciente; and, in the early part of February, produced from two to four whelps; in no instance more. The mothers licked them clean, and then utterly deserted them, but in no instance devoured them. One of the finest males I had broke loose, and, leaping a six-feet wall, attempted to make off; but being instantly apprised of the fact, I gave him chase with greyhounds and horse. I shall mention his peculiar action by and bye, and meanwhile shall only observe that, after a run of a mile, we suddenly came up with him and found him quite dead! The violent exertion after long confinement, proved too much for him; he broke his heart. All my specimens refused dressed meat, and were fed with raw buffaloe beef. Besides the grown animals, I procured one young one, in March, about a month old. I kept it in the kennel with the other dogs, where it lived for four months, and then died of diarrhœa. This little creature, too refused every sort of food but raw meat. As it grew up, it was suffered to go at large, and never attempted to run away. It was very frolicksome, and would play, for want of a mate, with its own tail—for, notwithstanding all its efforts to induce the other dogs to romp with it, one pup only out of several would have anything to say to it, and the grown dogs all avoided it. Its voice when extremely excited was a squeak. At all other times it was silent, and it never made the least approach to a bark, properly so called. When angered, it showed its teeth and applied its tail close to the buttocks, in the manner of the domestic dog. When gratified by caresses, it threw itself on its back, pawed the caresser's feet, and uttered its peculiar squeaking notes. It distinguished the dogs of its own kennel from others, as well as its keeper from strangers, and in its whole conduct manifested to the full as much intelligence as any of my Sporting Dogs of its age. But it was a shy shrinking creature, and rather unmanageable on that account, and it would not endure being tied up. When this young animal reached me, it had scarcely any taint of the villainous odour proper to its race—the consequence of youth merely—for as it grew up the odour increased more and more. The whelps, when born, have it not in the slightest degree,males and females,when adult, are equally infected with it.

The *Búánsú* is, in size, midway between the wolf and the jackal, being two and a half feet long from the tip of the nose to the insertion of the tail; and twenty-one inches in average height. It is a slouching, uncompact, long, lank, animal, with all the marks of uncultivation about it—best assimilated in its general aspect to the jackal, but with a something inexpressibly, but genuinely, canine in its physiognomy. It has a broad flat head, and sharp visage: large erect ears: a chest nor broad nor deep; a shallow compressed barrel somewhat strained at the loins; long, heavy limbs; broad, spreading, feet; and a very bushy tail of moderate length, straight, and carried low. Its colour is deep rusty red above, yellowish below. It stands rather lower before than behind, with the neck in the line of the body, the head unelevated, and the nose pointed almost directly forwards; the fore limbs, straightened; the hind, stooping; the back, inclined to arch, especially over the croup; and the tail pendulous. In action the tail is slightly raised, but never so high as the horizontal line. Though the *Búánsú* be not deficient in speed or power of leaping, yet his motions all seem to be heavy, owing to their measured uniformity. He runs in a lobbing long canter, is unapt at the double, and, upon the whole, is somewhat less agile and speedy than the jackal—very much so than the fox. In general aspect there can be no comparison instituted between the *Búánsú* and the fox: but one may illustrate him by such a comparison with the jackal. To a rather more full opened eye, better placed in the head, and provided with something like a brow, the *Búánsú* chiefly owes his less sinister and more dog-like expression of countenance—the effect being aided by a rather better forehead, and less elongated and sharpened face. The Wild Dog's ears are twice as large as the jackal's; his limbs considerably longer; and his feet larger and more spread out, not to mention the great tufts of floccy hair with which their soles are provided, and of which we find hardly a trace in the jackal's feet.

The fur or external covering of the *Búánsú* consists of wavy wool, and straight harsh hair—in Summer in nearly equal proportions—in Winter, two parts of wool to one of hair. The hair is, on the neck, 3 inches long; on the back, 2½ to 2¾ inches; and on the tail 4½ to 5 inches. On the face, ears, forehead, upper surface of the head, and legs, the hair is very short, closely applied to the skin and unmixed with wool. On the body in general it is longish, smoothly directed backwards, and rather loosely applied to the skin, by reason of the wool insinuating itself

between the interstices of the hair and ascending with it for two-thirds of its length. But on the neck and cheeks you have none of the more or less composed set of the hair elsewhere, those parts being shaggily dressed in hair, the set of which is irregular, but mostly outwards or porrect from the skin. The cheeks have in consequence the appearance of being whiskered; and the apparent volume of the head is thus greatly increased. The hams posteriorly are somewhat feathered; the belly and legs scarcely so. The hair generally has a four-fold annulation of colour, from the base thus; whitish, black, deep rusty, black—the first ring being very small—the second and third large and equal—the fourth, small. The visible effect of this distribution and proportion of the colours, aided by the reddish blue of the wool, is, that the animal appears to be of a full ferruginous red; the two basal rings being invisible and the terminal one scarcely noticeable from its smallness—not to mention that it exists only on the dorsal surface, and not on the sides; nor, of course, below, where the colour of the animal is yellowish and no rings are found. The tail towards its base is ringed with pale rusty and blackish—towards its tip the hairs are almost or wholly blackish.

The jackal, which is furred in a very similar manner to the *Búánsú*, has his hair likewise ringed in the same way. But owing to the largeness of the terminal black ring, and to the very pale tinge of the penultimate red one, the general effect is very different. The jackal in consequence appears to be pepper and salt coloured with a tawny tinge; whilst, as already observed, the *Búánsú* shows deep rusty red. Let us now recapitulate the colours of the animal in the ordinary mode of description. Whole superior surface, with outsides of ears and of limbs as far as the wrists and hocks, deep rusty red, sprinkled with black on the back: whole inferior surface, with insides of the ears and limbs, and also the lips and jaws and feet, yellowish: chin darkened and reddish: bridge of the nose brownish: terminal half and more of the tail, blackish. Bristles of the lips, cheeks and loins; long, heavy limbs; broad, spreading, feet; and a very bushy tail of moderate length, straight, and carried low. Its colóur is deep rusty red above, yellowish below. It stands rather lower before than behind, with the neck in the line of the body, the head unelevated, and the nose pointed almost directly forwards; the fore limbs, straightened; the hind, stooping; the back, inclined to arch, especially over the croup; and the tail pendulous. In action the tail is slightly raised, but never so high as the horizontal line. Though the *Búánsú* be not deficient in speed or power of leaping, yet his motions all seem to be heavy, owing to their measured uniformity. He runs in a lobbing long canter, is unapt at the double, and, upon the whole, is somewhat less agile and speedy than the jackal—very much so than the fox. In general aspect there can be no comparison instituted between the *Búánsú* and the fox: but one may illustrate him by such a comparison with the jackal. To a rather more full opened eye, better placed in the head, and provided with something like a brow, the *Búánsú* chiefly owes his less sinister and more dog-like expression of countenance—the effect being aided by a rather better forehead, and less elongated and sharpened face. The Wild Dog's ears are twice as large as the jackal's; his limbs considerably longer; and his feet larger and more spread out, not to mention the great tufts of floccy hair with which their soles are provided, and of which we find hardly a trace in the jackal's feet.

The fur or external covering of the *Búánsú* consists of wavy wool, and straight harsh hair—in Summer in nearly equal proportions—in Winter, two parts of wool to one of hair. The hair is, on the neck, 3 inches long; on the back, 2½ to 2¾ inches; and on the tail 4½ to 5 inches. On the face, ears, forehead, upper surface of the head, and legs, the hair is very short, closely applied to the skin and unmixed with wool. On the body in general it is longish, smoothly directed backwards, and rather loosely applied to the skin, by reason of the wool insinuating itself

organs. But having already described with sufficient particularity the body and legs of the *Búánsú*, I shall confine myself here to the feet, tail and head.

The feet are large and somewhat spread, pentadactylous before, four-toed behind. The fifth toe before is short and elevated, as usual; and at the back of the wrists is the ordinary callosity. The nails are strong and truncated by attrition ; and the soles of the feet are provided with the common number of balls or rests. These balls are made, as usual ; but every part of the inferior surfaces of the feet beyond the strict confines of the balls themselves, together with the interstices of the digits, is furnished with long, soft, loose, hair, projecting beyond the feet in every direction, and giving them an appearance of extreme size. I know no domesticated dog, but the Kabul greyhound which is similarly provided: and as both live in mountainous countries where their feet are apt to be cut by sharp edged stones and rocks, the purpose of these socks or sandals (so to speak) is probably to protect the feet from such injuries; since protection from cold can be no object in such temperate regions. The tail is of very moderate length, but extremely thick and bushy. The length is that of the jackal's tail, extending only just below the heel properly so called—the fullness considerably greater than in the jackal, but otherwise similar. In action, the tail is carried sub-horizontally; at rest, pendulously and always straight.

The head, with its integuments, is moderately elongated, broad, flat crowned, and low; the real breadth of the posterior part much increased in apparent size by the quantity and outward set of the hair on the cheeks: the face more seemingly than really sharpened—broad and short by comparison of that of the jackal—the eye, oblique and narrow, but less so decidedly than in the jackal; its pupil round: the ears, twice as large as in the jackal, broad, erect, subpointed, the posterior margin furnished at its base with the ordinary fissure: externally, covered with soft short hair, loins; long, heavy limbs; broad, spreading, feet; and a very bushy tail of moderate length, straight, and carried low. Its colour is deep rusty red above, yellowish below. It stands rather lower before than behind, with the neck in the line of the body, the head unelevated, and the nose pointed almost directly forwards; the fore limbs, straightened; the hind, stooping; the back, inclined to arch, especially over the croup; and the tail pendulous. In action the tail is slightly raised, but never so high as the horizontal line. Though the *Búánsú* be not deficient in speed or power of leaping, yet his motions all seem to be heavy, owing to their measured uniformity. He runs in a lobbing long canter, is unapt at the double, and, upon the whole, is somewhat less agile and speedy than the jackal—very much so than the fox. In general aspect there can be no comparison instituted between the *Búánsú* and the fox: but one may illustrate him by such a comparison with the jackal. To a rather more full opened eye, better placed in the head, and provided with something like a brow, the *Búánsú* chiefly owes his less sinister and more dog-like expression of countenance—the effect being aided by a rather better forehead, and less elongated and sharpened face. The Wild Dog's ears are twice as large as the jackal's; his limbs considerably longer; and his feet larger and more spread out, not to mention the great tufts of floccy hair with which their soles are provided, and of which we find hardly a trace in the jackal's feet.

The fur or external covering of the *Búánsú* consists of wavy wool, and straight harsh hair—in Summer in nearly equal proportions—in Winter, two parts of wool to one of hair. The hair is, on the neck, 3 inches long; on the back, 2½ to 2¾ inches; and on the tail 4½ to 5 inches. On the face, ears, forehead, upper surface of the head, and legs, the hair is very short, closely applied to the skin and unmixed with wool. On the body in general it is longish, smoothly directed backwards, and rather loosely applied to the skin, by reason of the wool insinuating itself

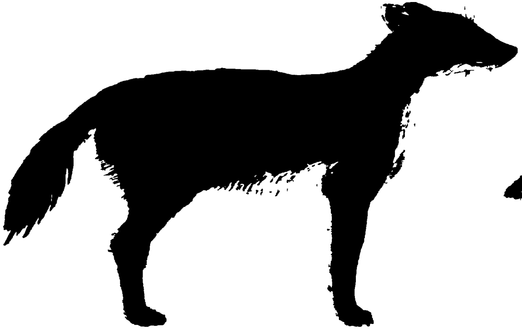
the posterior halves of them, instead of being bent concavely as they approach a considerably elevated forehead—as is the case in all domestic dogs are bent convexly, uniting insensibly with the arcuation of a low forehead. There is consequently very little transverse dip or depression in the fore part of the head: and indeed the entire vertical line of the skull approaches, by its pretty uniform and gentle curvature to that of the hyæna,—a form of head of which the true type is to be sought in the *felinæ:* Frontal bones, lower and flatter than in any domestic dog—rather higher and more arched than in the jackal, much more so than in the fox. Frontal processes or brows, small, but rather larger and fuller than in the jackal or fox. Frontal sinuses, not inconsiderable notwithstanding the lowness of the frontal bones; their want of development upwards and outwards being compensated by a larger longitudinal range than is usual with domestic dogs. The extent of *anterior* development of the frontal sinuses in the *Búánsú*, and their connexion with the nasal cavities and with the brain, are, in particular, more striking than in any domestic dog's skull I have had an opportunity to examine: and perhaps in these peculiarities, taken in connexion with the superior elongation of the cartilaginous portion of the nose, we may find the true explanation of the Wild Dog's superior powers of smell, despite the inferior development upon the whole of his frontal sinuses, as compared with that of the same sinuses in the spaniel. Parietals, as largely developed as in the spaniel. There is somewhat less amplitude anteriorly, near the frontal sinuses: but it is compensated by greater enlargement posteriorly and inferiorly. Great longitudinal and transverse cristæ, medial. Rami of the lower jaw, very little bent; and the condyles, consequently, scarcely raised above the line of the upper cheek teeth. The upper maxillary bones less compressed, and the lower jaws more separated, and the intermaxillary bones more widened to the front than in the spaniel; greatly more so than in the jackal. By reason of these peculiarities the incisor teeth stand nearly in a line as in the *felinæ*, instead of being bent into a segment of a circle, as in the *caninæ*. Jaws rather shorter than in the spaniel—decidedly so than in the jackal: and herein we must, perhaps, look for the explanation of that remarkable anomaly in the dental system of the *Búánsú*, viz. the absence of the last molar in the lower jaw.

Upon this point I expect to meet with abundance of scepticism in my scientific readers, which I shall only increase by telling them that the teeth have in *every other* material* respect the well known characters. It is the second tubercular behind the great carnivorous tooth that is wanting, all the rest having precisely the ordinary forms and positions. To remove as far as I can the doubts I anticipate, I beg to state that I speak upon the authority of no less than five skulls—three of old— two of mature —and one of a young but fully grown animal; that the deficiency of the lower molar corresponds with the diminished size of the last upper one; that this anomaly is in harmony with the somewhat less than usual elongation of the jaws, and with the consequent closer than ordinary arrangement of the false molars, which stand *anteriorly* to the carnivorous teeth, both with respect to one another, and to the canines.

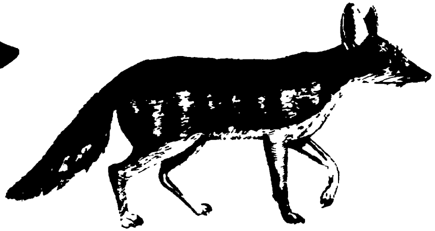
The more we see of nature the more are we convinced that in *her* scheme all generic and other distinctions, established by us, are by her insensibly blended into one harmonious whole. The *Búánsú* by his teeth, his jaws, and the form of his skull along the vertical line, tends to connect, although with a long interval, the Dogs, through the Hyæna Dogs and the Hyænas, with the Cats. But, it will be asked, if the *Búánsú's*

---

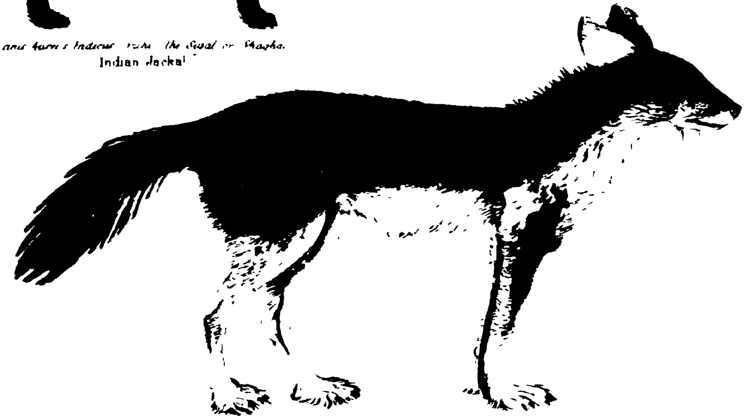
* The reserve implied by the use of the word material, refers solely to the slight difference immediately noticed in the text, viz. the closer set of the molars standing anteriorly to the great carnivorous tooth. These molars are, clearly though trivially, nearer to each other; and the foremost of them is nearer to the canine, than in any of the numerous skulls of tame dogs belonging to all three of CUVIER's Sections which now lie before me. A minute examination, tooth by tooth, has not enabled me to discover the least distinction between the ordinary canine dentition and that of the *Búánsú*, with the above exception; and, of course, that important one which is dwelt on *as such*.



Canis Aureus Indicus (nobis) the Sgal or Shagha.
Indian Jackal

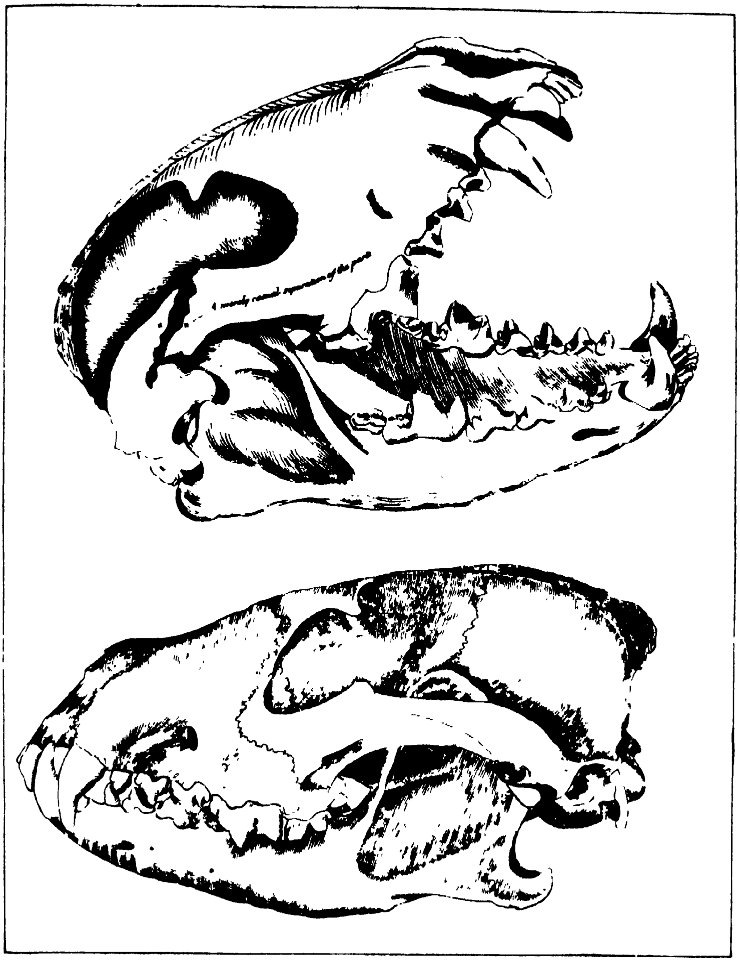


Canis Vulpes Indicus (nobis) the Lomri
Indian Fox



Canis Primævus (nobis) the Buansu of the Nepalese
Indian Wild Dog

J. R. Martin lith.


A merely casual separation of the parts

SKULL of the BÚANSÚ

J.B. Tassin lith

head has any resemblance to that of the Hyænas, why is not the *Búánsú* classed under Cuvier's Third Section of the Dogs distinguished by a short muzzle? and why is not this animal separated altogether, by reason of his dental system, from the dogs proper, instead of being made their archetype? In answer to the first question I would observe that I have ranged the *Búánsú* under the Second Section rather than the Third or First, from the preponderant character of the skull, derived from the greater number and importance of all those indications which belong to it. In reply to the second question I would say, much in the same way, that though the *Búánsú's* system of dentition be anomalous, the anomaly is of small importance in comparison of the whole of those peculiarities of entire form and expression, manners and habits which decide him to be a proper Dog: and that, assuming him to be such, there seems to be peculiar propriety in selecting him, an unquestionably wild animal, to be the prototype of his race in preference either to a half reclaimed variety of the Dog, or, to the wolf, jackal, or fox,—races, wild indeed, but such as the learned now at last are agreed with mankind in general in considering as distinct from the true Canine race. There are indeed difficulties lying at the bottom of this subject, as connected with larger question of the true nature and limits of species, which I pretend not to cope with; but until they are solved I deem it natural and philosophical to adopt the specifical differences and identities of the world at large. The *Nipalese* universally call the *Búánsú* a dog; and this general impression, derived from a much closer acquaintance with the natural habits and demeanour of the animal than Europeans can ever hope to possess, has, I confess, the greatest weight with me For the rest, and in conclusion, I crave permission to say to the querulou objector—*si quid novisti* &c. or, in a better spirit, let me exhort him to use my facts—reject my speculations—and substitute his own; creating, i he pleases, a new Sub-division of the *Digitigrades* characterised by one tubercular tooth behind the great carnivorous tooth in the lower jaw. H will find a vacant niche for such a new group between Cuvier's Second and Third Sub-divisions; and he has my full permission to place the *Búánsú* therein, provided he will pardon me for having relieved the toil of collecting and recording a multitude of facts by some little indulgence in the way of speculation upon them.

Dimensions of the animal.

	Ft.	*In.*
Nape to rump, ...	2	$5\frac{1}{2}$
Length of the head, ...	0	$8\frac{1}{2}$
Ditto of the tail (end of hair.)..	1	$4\frac{1}{2}$
Height, at the shoulder, ...	1	$8\frac{1}{2}$
Ditto at the hip, ...	1	$9\frac{1}{2}$
Depth of the chest, ...	0	$8\frac{1}{4}$
Length of fore-leg, to line of belly,	1	$0\frac{1}{4}$
Ditto of hind ditto ditto ditto,..	1	3
Length of the ears, ...	0	$4\frac{3}{4}$
Snout to fore angle of eye,....	0	$3\frac{1}{2}$
Thence to the occiput,........	0	5
Weight (thin) 30 lbs.		

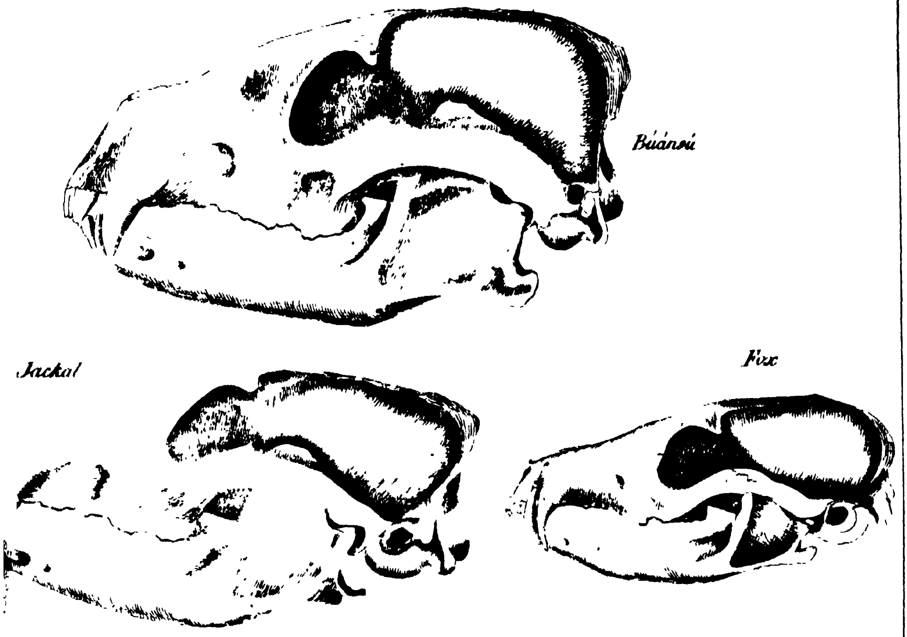
Dimensions of the skull.

	Ft.	*In.*
Extreme length, ...	0	$7\frac{5}{10}$
Extreme breadth (between the zygomatic processes,)......	0	$4\frac{7}{10}$
Extreme height, ...	0	$3\frac{9}{10}$
Greatest breadth between the temporal bones,..........	0	$2\frac{9}{10}$
Symphysis of intermaxillary bones to posterior points of nasal ditto,...............	0	$3\frac{1}{10}$
Thence to the coronal suture,	0	$2\frac{1}{10}$
Thence to the posterior extremity of the skull, or end of crista occipitalis	0	$2\frac{1}{10}$
Length of lower jaws from the condyle to the symphysis of the jaws in front, ...	0	$5\frac{5}{16}$
The same from the former to the posterior edge of the last molar tooth, ...	0	$3\frac{5}{10}$
Length of upper jaw, from symphysis of intermaxillary bones to posterior edge of last molar tooth, ...	0	$3\frac{9}{10}$
Symphysis of intermaxillaries to foremost edge of orbits, ...	0	$2\frac{4}{10}$
Thence to end of crista occipitalis,	0	$4\frac{9}{10}$

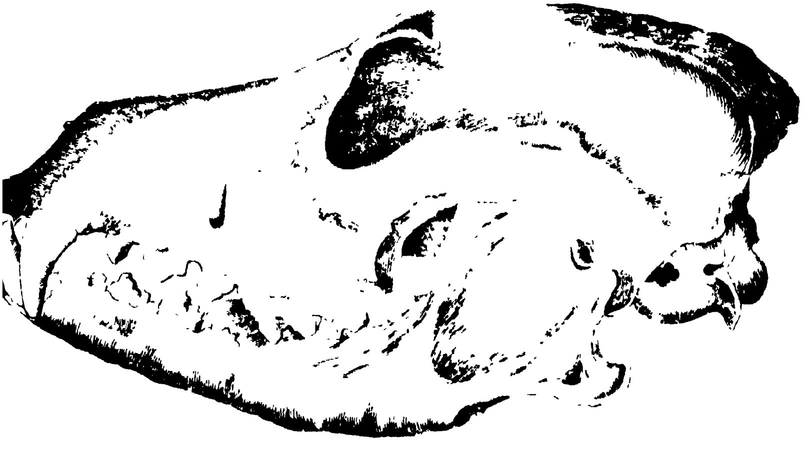
N. B. These latter measurements (of the skull) are rectilinear, taken with calipers—and not drawn along the curves.

NEPAL RESIDENCY, *July* 1, 1832.

ive view of the Skulls of the Wild Dog, Jackal & Fox of India, designed to show their general forms merely



Skull of the Páriár or Chien de Rue of India



awn lith

APPENDIX.

CANIS AUREUS INDICUS, scarcely differs, as a variety, from the type of Pallas and Guldenstadt: is two feet long and seventeen inches high: the head seven, the tail eleven and half, the ears three inches in length: Above, dark or iron gray, with a pale rusty tinge—below, whitish: tip of the tail and a patch on the chin and on either fore arm, blackish: weight twenty pounds. Feeds chiefly on carrion, preys by night, is fearless and familiar, found every where, seldom abroad by day, does not usually burrow.

CANIS VULPES INDICUS, new: has some affinity with the *Corsac*: is twenty-one inches long and twelve high: the head five, the tail twelve, and ears three and quarter inches in length: Above, pale or ashen gray, with a very pale rusty tinge—below, yellowish; a dark line from the eyes to the nostrils: Tail reaching to the sole of the foot, black-tipped. Remarkable among its congeners for the acuteness of its canine teeth and of its nails. Feeds chiefly on insects and vermes, preys by day and by night, constantly abroad by day, very familiar, resides in burrows on open dry plains, found all over India, excepting the hills. Weight seven to eight pounds.

XV.

OBSERVATIONS

ON THE

SPÍTÍ VALLEY

AND

CIRCUMJACENT COUNTRY WITHIN THE HIMÁLAYA.

By SURGEON J. G. GERARD,

BENGAL NATIVE INFANTRY.

PART I.

It had long been supposed upon theoretical inferences and conclusions, deduced from accordant but vague information, that the chain of mountains which defines a natural boundary beteen *India* and *Thibet*, recognised as the *Himálaya*, had a corresponding but less rugged declivity on the north, which sinking into a table land, undulated with a downward slope and spread out into a plain, and that the whole level of the soil immediately assumed an opposite declension to that of *India* on passing that lofty crest. But on crossing various ridges at elevations between fifteen and sixteen thousand feet in altitude, by the course of rivers which had their origin on the southern slope, the snowy zone was found to be of great breadth, and, instead of an insulated line of peaks, to present consecutive ranges, or detached clusters of summits rising in rivalry, and even transcending the hither precipitous cliffs which appear from our plains in such gigantic desolate grandeur. The passes into the interior of the country were observed to run upon a higher line of level, and the streams to ramify many days journey within the snow-girt region, as the branches of the *Ganges*, *Jamna* and *Chúnáb*, or like the *Satlej*, to pursue their course through the chain, deriving supplies from its northern skirt, and the high land at the back of the peaks, or penetrating more remotely, and receiving accessions from more inward regions and higher table land, as the *Indus*. In this vast alpine tract, no line has yet been discovered that marks an opposite slope to the rivers, nor have we any grounds of inference for the probable limit of that lofty level, of which the *Ganges* and *Indus*, with the *Panjáb* streams, may be considered as defining the southern declivity, and the *Brahmapútra* and *Oxus* the eastern and western slope; but nothing is known or conjectured of a northward or north-eastern boundary, and we still remain ignorant of the extent, the altitude, and the nature of the great central platform of Asia.* Lake *Mánsarovara* may be indeed assumed as the highest point of the Indian Peninsula, forming a plane which throws off the great rivers from south-east to north-west, and the base of clusters of peaks insulated between their sources and the northern slope of the plateau, of which all our knowledge is still confined to conclusions from the upper course of the *Satlej* and *Indus*, where the basins of those rivers, and consequently the lowest depression of the soil, have been ascertained to rest upon the zone of fifteen thousand feet, and the table land, through which they roll, to rise beyond seventeen thousand. These are but approximations to the altitude of the broken plains of *Tartary*, which only serve to prolong conjecture as to the extreme verge of the highest lines of level. All the waters from the northward deflexure of this mass of mountains, from the great *Kylás* chain and table land on both sides of it, running into the grand rivers, which form the Peninsula of *India*, or intersect the Gangetic plain, or tending towards an aspect comprehended between the debouchures of the *Brahmaputra* and *Oxus.* In crossing the remotest accessible points of the snowy barrier, or winding round the bases of its detached peaks, we find the declension of the soil every where, towards the hollows which drain off the southern waters, marked by innumerable rapid torrents throughout a reticulation of levels, which opening into a common trunk or lateral valley, pour their tribute into the great rivers

---

* Baron HUMBOLDT's Researches were not known to the author, when this was written.

On the north-western frontier of *British India*, the *Satlej* is the centre of this system of rivers, collecting in its downward course from *Mansarovara*, streams from the northern skirt of the *Himálaya* on one side, and the high table land on the other, which, rising in bluff undulations, terminates in a rival crest (*Kylás*) which sends its waters to the *Indus*. At the deflexion of the *Satlej* at *Shipke*, (Chinese Government), it receives similar feeders from the high ridge of *Paralássa* on the north-west, and others from the north, to the limit which turns the declivity of the soil towards *Ladák* and the *Indus*, and on the south the liquified snow of lofty mountains which have their corresponding base washed by the streams of the *Ganges*. In this area of intersections, the river *Spíti* is the great trunk descending from clusters of peaks at the heads of the *Chandrbága* or *Chúnáb*. It meanders through an inhabited valley, and debouches into the *Satlej*, at the village of *Namgeu*, in *Kunáwer*, where the stream is elevated eight thousand six hundred feet. Like the other *Intra Himalayan* rivers, its slope decreases with the rise of its course, opening out from a narrow rock-girt channel to an expanded bed of sand and alluvial sediment, and towards its source creeping sluggishly round the roots of the cliffs. At its conflux with the *Satlej*, it emerges from a gorge, or mere fissure, between perpendicular walls of granite rock.

At the villages of *Chango* and *Shiálkar*, twenty miles up the stream, the banks exhibit horizontal strata of water-worn pebbles, loam, marl, and finely attrited sand, with occasional imperfect traces of fossil exuviæ at heights from one to two thousand feet above the river's bed, or eleven to twelve thousand above the sea. The channel continues sharp, but is here little hampered by rocks. The mountains of a gravelly structure, rising out of the dell on each side to the verge of twenty-two thousand feet, are almost bare in summer, the marginal snow resting close to their tops in a narrow but well defined belt. At the fortified rock of *Dánkar*, the bottom of the valley attains its maximum expanse, which is here flat, sandy, and intersected by the stream: the mountains, forming a steep rugged boundary on each side, are indented by water courses, which, descending abruptly from the snow, swell the river to nearly the size of the *Satlej*. Villages and cultivation are thinly sprinkled along the banks. In summer, the climate is mild and even sultry, notwithstanding the great elevation of the soil, and dense crops of wheat, barley and pease ripen in August and September. The winters are proportionally rigorous, but the sun's rays are always extremely ardent, and when the ground is sheeted in snow the reflected glare is intolerable to the eyes.

The forks of the river are near the village of *Lossur*, the last inhabited spot in the dell where the stream has an actual elevation approaching to thirteen thousand four hundred feet, winding with a slow declivity in a broad pebbly bed round the feet of the mountains, here presenting an almost mural scarp to their near summits, which are flat or slightly inclined, but the ravine continues beyond *Lossur*, and receives the remotest feeders from the recesses of the *Paralássa*, which is here the limit of the plane, and gives a northward slope to the waters in the origin of the *Chínáb*. The valley of *Spiti* is thus comprehended between the heads of that river in latitude about 33°, and the *Satlej* in 31° 45′. The course is south east, flanked by snowy mountains on one side and the declivity of a loftier chain sloping to the table land of *Rúpshú* on the other; the more precise boundaries of the district being, the hill-rajship of *Kúllú* and the *Himálaya* south-west, the *Satlej* and the British Territory of *Basáhir (Kunáwer)* south-east. Snowy ridges and high tabular land to the *Indus* north and north-east, and the *Paralássa* mountains with the branches of the *Chandra Bága* north-west, including an area of about ten thousand square miles drained by the *Spíti*. From the southern base of the snowy zone to the valley of the river is a geographical distance of fifty miles, and an equal space in the same line of direction (north-east) falls over snowy mountains, belts of table land and ridges, which, though only capped with snow, do not yield in elevation. The great lines of level continue rising to the *Indus*, and the land, sloping up to the north by successive ranges, at last opens into a continuous plain inhabited by Nomade races, who live in black tents, and migrate with their flocks in search of pasturage. These are the *Huns* and *Mongols*, whose figures are described as very hideous. All hither to that limit, including the upper portion of the *Satlej* and its ramifications and even the valley of the *Indus*, considered by European geographers as table land, is but the rugged skirt of this great plateau; a tract of country unseen by the eye of civilized man, and almost inaccessible to the natives of any other region. The skies are here so arid that little snow falls even in winter and is only perennial in the loftiest spots. The section of country made by the *Spíti* and its tributaries, though cutting the northern base of the *Himálaya*, presents a singular contrast to its opposite or plainward aspect, not only in climate and vegetation, but in the condition and character of its inhabitants, and in geological structure, the rocks themselves appearing new and all the productions of nature different.

A traveller entering the valley by the sources of the *Chúnáb* and *Paralássa* chain on the north-west, and tracing down the river, particularly remarks the steep and insular form of the cliffs on each side. Where the hollows of streams take their course, they appear like lofty islands with their erect bases, planted in the sand, and their almost mural sides ending in a flat top on a plane sloping outwards. Near the head of the valley these tabular masses are sheeted in snow. In the descent of the river the marginal rocks terminate in a sharper crest, and sink with the level, but the snowy zone upon the north, though more remote, preserves a very lofty line, displaying erect peaks with slanting summits, like the crest of a wave that has gone by. The structure of the rocks is generally a packed or scabrous limestone, the stratification of which is arrayed in nearly horizontal belts, super-imposed upon each other in layers like benches, having their vertical faces to the river, and their dip inclined outwards at a very small angle with the horizon, which gives their declivity a very regular slope, that sometimes breaks off abruptly, but commonly softens into heaps of soil, like the undulations of the sea, producing furze pasturage for cattle: but the faces towards the river are too steep and rugged for any species of vegetable covering. The entire features of the country are extremely arid, with no natural verdure or cultivation, except through the medium of irrigation. The valley is but thinly inhabited, owing to the absence of streams for agriculture; the villages are consequently far detached along the step of the river, at a varying level between eleven and fourteen thousand feet; yet cultivation which, upon the Indian exposure of the mountains, shrinks and ceases beyond nine thousand five hundred feet, here maintains its ground and assumes even a denser character at belts of elevation, which often correspond to the marginal limit of the snow upon the southern aspect of the mountains, or the line of fifteen thousand feet. These cultivable spots occur along the course of adjunct feeders of the *Spíti*, or in open hollows facing to the sun between the marginal rocks of the dell and the parent ridge which defines the levels on either side. These villages, though subjected to night frosts during more than three parts of the year, and the keen rigors of a protracted winter, are more densely tenanted than those in the trunk of the river, where the patches of soil for cultivation are dry, rocky and baked; and the fields, eaten away by the stream on one side, and hampered by the attrited splinters of the cliffs, (which are constantly accumulating,) must in time become extinct. This desolating influence, though slow, is irresistible, and all the villages will eventually disappear under it, and the whole shelf of the river be turned into a desert: the very cause which has opened the country to the abode of mankind, will overwhelm it, and when the mountains, from gradual abrasion, no longer bear any snow, the river itself will be dried up.

The tributary villages, or those not actually in the dell, are planted high above and behind the terminal rocks upon a waving slope in the midst of a black argillaceous soil, which from its open situation, is permanent. The loftiest tenanted spots that have been barometrically determined, rest at fourteen thousand seven hundred feet, and crops of beardless barley extend to the verge of fifteen thousand. Men, animals, and vegetable productions succeed better here than in the valley below, all thriving profusely in a zone that contracts and terminates every trace of plants in the Andes under the Equator; nor is it at all improbable that the interior and flatter continuity of the country may nourish a cultivable soil in a much loftier region, where increasing aridity and solar reverberation tend to a higher limit of the Isothermal lines. At the extreme altitudes where grain ripens in *Spíti*, the summer temperature, though considerable, is of very short duration in an atmosphere where the heat dissipates so rapidly that the nights are keen even in July; hoar frost sometimes appearing near the fields upon the highland and vallies of *Rúpshú*, where the want of water for irrigation baffles all attempts at agriculture. It freezes throughout the whole year, and so early as the middle of September, the morning temperature was found between 13° and 17°, while in the day time it reached to 58°. Upon the declivity of the *Spíti* valley, in the early part of October, at permanently inhabited spots, the thermometer usually pointed between 14° and 16°, once 12°, in a hollow surrounded by dead sand hills, and five thousand feet below the level of the eternal snow; thus giving a frightful presage of their winter, against which the people are, however, well provided through the Sun's unintercepted rays and their comfortable houses, their clothing, and even their food; but fuel is so sparingly procured, that during the day a fire is rarely to be seen, though always at command amongst people who, enslaved to tobacco-smoking, are individually accoutred with flint and steel, and the furse so dry and brittle as to ignite even when growing.

Animals of every description derive a woolly covering from the effects of their arid climate. The *yák*, the dog, and even the horse all partake of this provision of nature, but the human race in this respect is more defenceless than in other Asiatic countries, being denied all beard, while their black bushy heads seem to be insensible to the *Thermal* changes. The *Lámás* or Priesthood are, by their creed, always uncovered, and their black hair being thick set and closely cropped, give them a frightful appearance, like Banditti. There is a characteristic aspect here in every thing, which betrays a foreign influence. From the soil to the skies the whole is new to the eye and strange to the feelings. In animal life, this is peculiarly displayed in the shawl goat, the *yák*, and a species of sheep; and to the dryness of the climate more than to its rigors is owing the singular physiognomy of the landscape. The silky softness of the goat's fleece, and even its existence, depends upon the arid air and vegetation; all attempts to naturalize it even in adjacent tracts, however cold, have failed, and must continue to fail even upon a more precise principle than that which regulates the migration of plants, for it is not heat but moisture that is here inimical, and both are combined immediately on passing the snowy crest towards India. In their own country, their only pasturage is tufts of spiked gramina, so brown as to be scarce distinguishable from the surface of the excoriated rocks—for when removed from under their native skies to however elevated a region, they cease to live. Solitary individuals out of large flocks have, indeed, by great care survived a certain period upon the hither side of the *Himálaya*, and have even reached the plains of India;—but in no country apart from their own bleak elevated pastures, can the species be preserved. It is the same with the *yáks* and the sheep which have black heads and feet: they may be acclimated upon the very border of their native soil, as in *Spití* or *Kunáwer*, but the wool degenerates, and the animals themselves outgrow their status and proportions. On transplanting them to the southern hills where vegetation is rank and verdant, they find no nourishment, droop and die; those which survive exchanging their soft fur for one of coarse hair. Even in neighbouring districts, beyond the influence of the periodical rains, and in a very cold climate, though the animals seem to thrive, the fleece of the goat deteriorates, and upon the hither side of the *Himálaya* becomes extinct. The deserts of *Thibet* are their natural soil, where they feed upon a prickly stubble or heathy like grass, scarce visible to the eye, yet myriads of these beautiful animals checquer the almost barren slopes of the mountains to which they seem destined, and it is futile to pursue the experiment of acclimating them to European countries, which will be found a mere illusory advantage, for even if they survive, it is certain that the third or fourth generation will lose their identity, and the fine wool entirely disappear.* The sheep of the table land have an equal peculiarity of habit, and are even more difficult to naturalize.

---

* Captain TURNER, who visited *Thibet* in WARREN HASTINGS' Government, brought down several Yáks and Shawl Goats, which were transported to Europe in safety, and a Yák actually lived in Mr. HASTINGS' park for several years. Mr. MOORCROFT was equally fortunate in the Goats he carried away from the Table land near *Mánsarovara*, which also reached England. Those subsequently imported into France have indeed survived under the advantages of a route by the Caspian sea, through an arid country, and the care of a Physician who expressly attended them, but though the animals are considered to be thriving, it remains to be seen whether the fleece will preserve its natural softness.

They are remarkable for size, and the quality of their wool and flesh, and a long and very small black head, with legs and feet of the same colour. These immense animals are used for the transport of grain, salt, tincal, &c. &c. They pasture upon the leafless plains of *Chúmurtí*, and the high table land, all along the forks of the *Indus*, being indigenous to the whole of *Thibet* from the limit of *Yarkand* to the east of *Lhassa*. They come down in vast flocks to *Spití* in the autumn for grain, but though here in a tract of country arid and desolate to the last degree, they cannot be reared with any advantage. In the deserts occupied by the Nomade tribes, both the animal and its fleece reach a finer standard, and there the climate is drier, and vegetable productions more scanty. Horses alone undergo the transition from their elevated pastures, but they lose the woolly covering that invests the roots of their long hair: the wild animal has never been domesticated in any situation. Both would appear a priori to have a common origin, yet the circumstance of their eluding every attempt to tame them when caught, and their uniform speckled colour of fawn and white, and their wild agility, demonstrate them to be distinct species.

The inhabitants of *Spití* afford even ampler traits of distinction than the animals; a community of condition arising from individual penury has generated reciprocal ties of social attachment. Though poor in those resources which denote easy existence, there is nevertheless a degree of comfort in the necessaries of life amongst the lowest classes unknown to the natives of the southward hills, where indolence and insulated habits have alienated those feelings of concord which make even poverty agreeable.

The common repast of the *Thibetans* consists of a greasy soup, called *Lappa*, and buttered tea: animal food is also naturally abundant in a region where pasturing flocks are almost in a state of nature, and in every house may be seen the dried carcasses of sheep and yáks, and skins of fat and butter. They are much addicted to tobacco and fermented liquor, and upon the whole the comforts of life are in their kind neither sparing nor unsubstantial. Their manners partake of the grossness of their food ; no feeling of female delicacy prevails here, and a promiscuous familiarity and coarseness in all the habits and decorum of life reign everywhere. Their wearing apparel accords with the exigencies of the climate and the suddenness of the thermal changes From the sheep-skin tunic to the chintzes and fine silks of *Lhassa*, which last are the insignia of the higher classes, or from the *Vazír* of the State to the Nomade of the desert, there is little in education or manners to denote distinction. Authority here, as elsewhere, claims a certain respect ; but the only courtly deference I observed in my interview with the *Khárpán* of *Ladák* (and this seemed to be due to me rather than from me) was during dinner, which we eat together in the midst of his greasy attendants, who devoured the fragments with voracious appetite, licking their fingers and then their plates, which were afterwards lodged within the folds of their woollen garments, or between them and the skin.

Strangers, especially Europeans, arriving amongst them and passing rapidly on their way, see nothing in the country or inhabitants to raise a favorable impression in their mind. They observe them in black bare-headed groupes, timid, squalid, and in rags, and every third person a priest; but, however unintelligible their conduct when debating in an unknown dialect about supplies, or the propriety of our progress, (both of which are doubtful in such a territory,) in their houses we were treated with friendship and hospitality, unaccompanied by that savage feeling which protects a traveller as a guest, and betrays him beyond the threshold of his sanctuary.

The complexion of the people is darker than might be assumed from the influence of so cold a climate, but the solar beams are equally or more ardent in an atmosphere, which, by its want of humidity, excoriates to brittleness every trace of vegetation, and parches to a ruddy and scabrous coarseness the skin of the face, especially in the females. The people of both sexes are naturally indifferent to shame, and alienation of chastity in the females is here a mercenary interest purchaseable upon the lowest terms. In figure they are stout, waddling and dumpy; in address, presuming and indecorous, but much of their open familiarity is the offspring of immoderate curiosity. In face they are not beautiful, even when young; when past their climacteric, very unseemly; and when old, a picture of horrid ugliness; not regardless of the aid of artificial charms, their hair glistening with rancid oil hangs loosely round their sun-burnt necks: sometimes it is woven into tresses which braid the contour of the face, but is commonly unregarded and blows out in the wind, giving them a shaggy appearance like wild beasts: their black greasy heads are embellished with *lapis lazuli;* their sun-burnt necks with amber and coral, their wrists and ancles with snow white shells, and a girdle of beads and other trinkets, all shining in the sun's rays. The men, without any superior pretensions, have their peculiarities less out of place, but they are black, greasy and imbecile, without any noble qualities whatever. Poverty and their insulated situation have denied them all pride of distinction, and subdued their feelings to one uniform level. Such is their general character, and it will apply to the whole nation of *Thibetan Tartars.* The absence of female chastity is a singular commentary to their honest and pacific conduct and the other social qualities of their natural society.

The country is every where broken into steep arid peaks, uniform sterility covering alike the mountains and the vallies. There are none of those fine contrasts of scenery which we behold in the southward regions of the *Himalaya,* where all the beauties and all the horrors of Nature are united together in a single precipice. Cultivation is here solely indebted for its existence to irrigation, and this nutritious impulse in so dry a climate is far more powerful than the spontaneous efforts of the soil, in quarters where the effect of atmospheric heat and humidity is combined. To the climate, vegetation (such as it is) owes nothing, but rather succeeds in spite of it. The few traces which are sprinkled over the dead sides of the cliffs shoot out of the rock as if impelled by their own vitality, but in the loftier zones, where the soil is better and the solar warmth mitigated, there occur upon the slope of the strata extensive tracts of a thick set prickly bush, which in appearance resembles the surface of a Highland heath.

The villages in the valley itself are planted upon an alluvial slip on each side of the river at long distances, and are indicated in summer by their verdant environs, and in winter by their black appearance in the waste of surrounding snow. The crops of this region are dense, but have little variety. The staple grain is *Ooa Jáo*, or beardless barley, peas, turnips, and in a few spots *Phapra* and mustard, the seed of which last is expressed for oil. The fields are sown in April and May, the seasons varying with the level, and in the elevated belts by the hollows of tributary streams; where the winter is protracted, the soil is cleared of snow by sprinkling black earth over it.

Notwithstanding the almost perennial night frosts at those extreme limits, and the severity of the climate during the sun's southern declination, the crops are even denser here than in the dell below.

As the cultivation of farinaceous grains chiefly depends upon a certain degree and duration of heat (which, in these regions, is found quite sufficient in July and August, without relation to the rigors of the previous or subsequent months), it was an oversight which this physical fact led to in the inference that the *Ooa Jáo*, or Tartaric barley, might be acclimated to the mountains of Northern Europe. The excessive cold that reigns at the highest cultivable levels of the *Intra Himalayan* regions during the greater part of the year, in no way cramps the progress of vegetation, since this is effected by the necessary quantity of heat during the appropriate season, and which, though perhaps never so considerable as in Southern Europe is more constant: and the solar rays of this parallel of latitude, in so thin and transparent an atmosphere, are infinitely more powerful; to such an extent, that the difference between their direct ardor and the shade is often more than one hundred degrees, and the contiguous slopes of the same ridge, within the space of a few hundred yards, present torrents of liquid snow and streams of unthawed ice.* These facts, and their effects upon the constitution of men, animals, and vegetation, are not properly understood in Europe, or if known, are explained upon theoretical assumptions which have no grounds of existence in nature.

The feebleness of the sun's rays in any part of Europe must render the mountain acclivities, of even moderate elevations, inimical to the success of the Tartaric grains, though the degree of cold there never approximates to that which reigns in the high zones of *Spíti.* Of this we have analogies on the Southern or Indian slope of the *Himálaya*, where, in a distance of only a few miles, and frequently within a few hours' journey on the corresponding aspects of the same ridge, we find cultivation checked, and altogether extinct on the verge of ten thousand feet, owing to the insufficiency of the summer heat at this limit, notwithstanding that the winter season here, in respect to mere cold, is far less severe, and the mean value of the climate much superior to that of the *Intra Himálayan* regions where grain is exuberantly cultivated. The climate of *Spítí*, notwithstanding the great elevation of the soil, unites the extremes of sultry heat and excessive cold; while the sun's rays are always intolerable, and in winter, strike with an ardor proportionate to the keen rigidity of the ambient air. At this period, when the country is sheeted with snow, exposure scorches the face and inflames the eyes even to the loss of sight, the glittering expanse is here made more brilliant by the reflection of skies of the deepest azure, even as black as ebony. On the first day of November, after a fall of snow, and in a temperature of 25°, I was fatigued by the sun's rays striking through a thick coat, and while feet and legs were undergoing a constant transition of thawing and freezing, to me at least the solar heat felt the most distressing, till the road deflecting round a bluff angle on the margin of the river brought us into the shade, where a bitter cold struck us to the bones, congealing the moisture of respiration, and the clothes on our backs and our legs, which in the ford of a torrent, came out at each step stiff with ice. From this time the mercury daily pointed near the zero of the scale, once two degrees below it, and probably did not rise, and must have fallen many degrees in the subsequent four months. What the cold arrives at, when the sun reaches his southernmost declination, is a conjecture that may be safely hazarded at—20° or—25° for the inhabited spots in the valley, and at the villages on either side of the limit of nearly fifteen thousand feet, it can be little above the freezing point of mercury

---

* It will scarcely be credited that in the beginning of September, upon the Northern slope of the Paralássa, at an elevation of fifteen thousand five hundred feet, a thermometer resting upon the rocks marked 158°, while the temperature of the air was 55°, —again in the middle of October when the Sun's Southern declination is already great, at the Chinese village of *Langtcha*, elevated more than fourteen thousand five hundred feet, the sun's rays absorbed by the sand had a temperature of 130°, while the air was 46°. In the end of the same month, in a valley flanked by lofty rocks, but at an elevation of twelve thousand feet, a thermometer stood in my pocket at 105°. Wherever we go we find the sun's rays oppressive, and much of our surprise at the high zones of inhabitants, and cultivation, ceases when we become acquainted with these circumstances.

The winters are followed by a degree of warmth equal to the summers of the south of England, and a far more powerful sun, but with a more variable diurnal temperature. Upon the elevated table land of *Rúpshú*, or at the tenanted environs of *Spǐtí*, whatever be the degree of midday heat, it flies off so rapidly in the thin air, when the sun ceases to shine, that the nights of those regions offer an extreme contrast in their chilliness, the range of temperature in the twenty-four hours often exceeding 40°. In insulated elevations this would not amount to 15°. Towards the end of August, the climate of the middle regions of *Spítí* had a day temperature of 83°; and clouds of dust wheeling along the river bed, and sometimes a weak and transitory peal of thunder gave the scene a more tropical complexion than would readily be conceived possible at an elevation between twelve and thirteen thousand feet above the sea, and in a parallel of 32½° of latitude. At *Dankar*, which verges upon this last level, my small tent was but a feeble screen against the solar rays, the thermometer on the table rising to 110°; but in so rarified and elastic a medium this accumulation of heat is very fluctuating, for, when it rains, the air at midsummer is chilled down to a degree very uncomfortable to the feelings, and the cliffs in the immediate vicinage of the villages are often sprinkled with fresh snow. In the vallies of *Rúpshú*, at a mean elevation of sixteen thousand feet, where the maximum temperature may be estimated at 75°, it snows occasionally in July, and freezes always at night*; yet such and even loftier situations are the pasturing regions of innumerable flocks, where it is difficult for the eye to detect any nutritious vestige.[*] The marginal limit of the snow, which upon the sides of *Chimborazo* occurs at fifteen thousand seven hundred feet, is scarcely permanent in *Thibet* at nineteen thousand, and upon the southward aspect has no well defined boundary at twenty-one thousand feet. From an altitude approaching to that line, and which was bare of snow, I was in view of a distant chain, the detached peaks of which appeared under an elevation of some minutes; yet a few traces of snow, like ribbands, only remained on the last day of August. My own position was here at the edge of the snow, from which to the bed of the *Spíti*, at a perpendicular depth of ten thousand feet, was a continuous bare slope. The opposite (northern) declivity was indeed sheeted in snow to the bottom of a deep dell, and all beyond me was uniformly white.[†] If the objects

---

* MOORCROFT, in traversing this tract at midsummer, encountered a fall of snow, which however vanished during the sun's course. M. CSOMA DE KÖROS, the Hungarian traveller, had a more frightful picture of the rigor of the climate in an adjacent tract *Zanskar*, where, on the day of the summer solstice, the ground was sheeted with a fresh fall of snow, and in the beginning of September the same scene was renewed while the crops were still uncut. MOORCROFT when encamped on the shore of Lake Mansarovara, had his tents covered several inches deep with snow on the 10th of August, with frosty nights in July, when approaching the forks of the *Indus*:—facts of themselves (in so low a parallel of latitude,) demonstrating vast height, and in connexion with analogous observations upon the Isothermal lines in *Rúpshú* (if we had not Barometrical levels of the *Satlej* at *Shipké* and *Bekhar*, and Captain WEBB's depression of the river from *Niti* pass) affording presumptive inferences for placing that lake upon the very verge of seventeen thousand feet.

---

[*] A late traveller, M. TEMPLAND, has discovered in the Peruvian Andes similar scenes to those in *Thibet*, the level of towns and cultivation having there an altitude of between twelve and fourteen thousand feet, and the highest inhabited villages and fields rising to nearly sixteen thousand. The crest of the mountains is proportionally elevated, two peaks having been determined at twenty-four thousand and twenty-five thousand five hundred feet respectively: the *Himálaya* are still superior in actual height, and greatly surpass the Andes in the medium of a large tract of lofty level, and the interior regions, which already begin to present a more gigantic display, are wholly unexplored.

[†] This spot is upon the northern verge of *Kunáwer*, conterminous with the Chinese frontier, and immediately above the Hamlet of *Changrezing*. The extreme ascent was effected upon the 31st of August, the preceding night having been passed at an elevation of eighteen thousand feet. even here we found ourselves so much exhausted by the rarefaction of the air that every movement was an exertion. Though the wind had a temperature of 42°, the sun's rays were so harassing as to force us to screen our faces, and for my own part literally to envelope myself in a blanket.—Somnolency, languor and sickness affected us so much that we lay all day in hollows amongst the rocks, without thinking of our situation or the chilliness of night. We slept in the open air under a calm resplendent sky and a temperature of 19°, that of the ground we lay upon being 14°, yet we did not suffer great inconvenience except when the puffs of cold wind crept in upon us, and congealed the moisture of respiration. The ascent from this spot (short as it was) occupied us upwards of three hours, and latterly our progress was beset by debility and such a sense of suffocation from the partial inflation of the lungs as almost overpowered our utmost efforts to move. I do not think we could have ascended much higher at that time, had it been practicable. At 1 P. M., the Barometer stood at 14,220 inches in a temperature of 30°, which computed from cotemporary observations at Calcutta, indicates an altitude exceeding twenty thousand and four hundred feet, a result which may be depended upon as being

I beheld from this lofty station were fifty miles distant (and the eye traversed a large tract of intervening country,) the difference between the apparent and true level would of itself amount to fifteen hundred feet,

---

farther verified by the observation of several contiguous peaks, whose height had been fixed trigonometrically from various lofty positions by my brother, Captain ALEXANDER GERARD. One point, in particular, which flanks a pass communicating between *Kunáwer* and *Spiti*, and elevated twenty thousand and five hundred feet, had the smallest appreciable depression, and the convexity of the level at the distance of my station, absorbed the trifling excess of height in the peak. On my north was a detached group of white tops concluded, from the angles they subtended, to be twenty-four thousand feet above the sea ; the marginal snow occupying a very narrow belt, but the surface unbroken by a single dark peak. Beyond them appeared the chain of bare peaks in a very sharp outline. I took the angles of various points. Some were upon the plane of my own level, but generally all were a few minutes higher, and as the view was intercepted by an adjoining ridge, I could not ascertain the limits of their height or extent. Their sides were very precipitous, and from their reddish and often pale appearance, I concluded their structure to be gravelly or of sandstone, of which their configuration gave every sign. Their steep and conical crests seemed to have assumed that form by the wearing away of the surface : some were entirely naked, and where the snow rested, it was in patches or stripes in the course of hollows. The ground at their base was very rugged, and had an apparent elevation of eighteen thousand feet, the rock displayed itself below like granite, overtopped by the red formation ; whatever it was, I am the more inclined to this belief from the occurrence of vast blocks of granite in a gorge which crossed my ascent, having been disclosed by torrents from the snow ; while, at my nearest appulse to the summit, the rock was not connected, and seemed to run into a secondary series. The extreme tops at an estimated altitude of between fifteen hundred and two thousand feet higher were perfectly white, and had a bluff contour as if derived from the elements of their structure. The highest point of the bare ridge appeared at the verge of interception by the slope of an adjacent mass of mountain which was cut off from my position by a deep dell, but I have no doubt that loftier objects were to be seen, those in view being sufficiently indicated to authorize the inference, and being accessible points as far as physical obstacles are concerned, they hold out to adventure a prospect full of interest with relation to the structure of such elevated masses, and the observation of the unknown regions beyond them which have not even a mark in our maps. The sun's rays were very distressing here, but they seemed to be showered down with triple ardor upon the chain of conical peaks till they glowed in the effect of their desolation like a towering outline of volcanoes, to which impression their form and aspect bestowed an image of reality. Some very distant snowy peaks glittered in the horizon towards *Rupshú*, but the great chain which lay to my north in passing over that tract was not visible, and as it runs behind the bare ridge and is sheeted with eternal snow, its summits must be vastly elevated. Part of the same chain was, however, descried from *Parkeúl*, rising out of the table and in a line of whiteness, my own level being here nineteen thousand and five hundred feet, and the intervening country between me and the objects a little under it all black :—a still more eastern portion seen from near *Bekhar*, had an appreciable angle of altitude from a base of eighteen thousand two hundred feet, and at a vast distance.

but some of the points subtended an angle approaching to half a degree, thus arguing an absolute height exceeding twenty-two thousand feet free of snow. The outline was very steep and sharp, and the peaks of a reddish colour, from a gravelly or sandstone structure, had a most desolate appearance. The contiguous level, though very lofty, was still rugged, and where the surface of the country is more even, we may conclude a greater altitude for the seat of perennial snow; and it would seem from the oral accounts of the *Lámás*, that the inward and still distant ranges confining upon the Tartaric plateaux, exhibit no snow that rests throughout the year, not owing to any depression of the soil, but to the constant shining out of the sun; and it is no vague conjecture to entertain that tracts of land will one day be discovered, where the abodes of mankind and cultivation surpass in height the summits of the Andes, having the winters of the Polar regions, without their snow, succeeded by the summers of England.

The peculiar aridity of the *Intra Himálayan* regions is a subject connected with so many meteorological phenomena, and with so much of the conveniences of life, that it seems to open a new field to the philosopher. Things do not .rot in *Thibet*, but crumble in long ages. There are neither moisture nor insects to produce decomposition. Every thing desiccates, and, as it were, stands fixed: the process of decay is slow, and superficial things gradually disappear in dust. Where there are no forest trees, timber is of great value, but here it lasts for centuries, and the roofs of the houses constructed of an argillaceous earth are actually baked by the sun's rays, till they harden like the *kankar* of the plains. Where little rain or snow falls, there are few natural agents of destruction, and we see neglected Monasteries yielding slowly to time, each winter eating away portions of the walls, while the timbers remain unchanged. Ruins in *Thibet* are the records of far antiquity; books are imperishable, for no insects attack them, and there is every probability that literary memorials of the earliest periods may be extant in a climate and position alike favorable to their preservation. If any Antediluvian relics of the human skeleton are to be found at all, they are likely to be discovered in some part of this elevated platform.

The hygrometrical state of the air produces more important physical effects than either heat or cold, for it gives a new aspect to a country; and, in this respect, *Spíti* may be taken as an index of the physical constitution of the vast regions lying beyond the *Himálaya*, and its consideration will assist to explain some of those anomalies which have opened upon us in that hitherto unexplored quarter.

The traveller in *Thibet* is struck with the difference in the aspect of opposite sides of a ridge having in many places not more than twenty miles in breadth. The masses of ice resting in hollows of the bare rock near which no snow is visible, where the sun's rays are scorching, and the temperature of the air is very mild, for though elsewhere it would thaw in a temperature above 32° it remains permanent here at nearly 50°. I have seen torrents frozen solid in the beginning of September, where the ambient air of the spot kept the thermometer at 57°, and the ice did not appear to drop. In the southern hills, in the dry and clear months of November and December, it is usual to see water freezing in a temperature of 46°, at an elevation of four or five thousand feet above the sea, or under a barometric pressure of twenty-five to twenty-six inches,—but by increasing the density of the air by descending to a lower level it requires a much greater degree of cold to produce the same effect, and under circumstances of excessive moisture, a thermometer will fall below the freezing point and no frost take place. Cotemporaneous observations made between various parts of the hills and stations on the neighbouring plain in the latitude of 31°, have verified a fact which theory has scarcely indicated, and scientific inductions (as far as I am acquainted,) are almost silent upon

The different effects produced by various degrees of rarefaction of the atmosphere and its relations to moisture are such as make the thermometer cease to be a correct measure of temperature, for it is not the actual, but the sensible quality of it that is so important to philosophical studies. The superincumbent atmosphere upon the surface of the *Gangetic* plains in the months of November and February, when the thermometer frequently falls below the freezing point without ice being formed, is an instance of cold without its due effects, while in the mountains at a height of seven thousand feet, as at *Simla*, a much higher temperature will freeze the soil a foot deep. The sensibility of our feelings to those atmospheric influences is but too delicate. Let one contrast the damp morning chill of the plains with the frigid elasticity, and even stimulating effect of the mountain air which, perhaps ten degrees higher, gives the aspect of an European winter. In one case the air being loaded with moisture, and absorption farther checked by its density, a film of ice is only produced by a temperature of 28° or 30°. In the other, the air is so dry and subtle that it freezes by the effect of evaporation more than by mere cold. In the *Intra Himalayan* regions this power is so much augmented by aridity that ice often disappears unthawed while snow has been seen to fall when the temperature pointed to 47°. In the southward hills the air must be cooled down to 37° before this takes place.

Every person in *India* is familiar with the peculiarly mouldering nature of the rainy season, though the heat is perhaps tempered fifteen or twenty degrees. It is the moisture which is here the element of structural decay and of oppression to our feelings. In *Spíti*, yaks are killed in the end of September, and hung up to dry when the mid-day air is at 66° or 68°. It is the absence of moisture here, that produces the opposite state, which is so sharply defined, that all the productions of nature, both animal and vegetable, would appear to be an effect of it rather than to owe their peculiar form to distant species. To this accelerated vaporization is owing the fluctuation in level of the lakes in *Tartary*, in defiance of increasing cold. The lake of *Mánsarovara* celebrated in *Hindu* mythology for giving efflux to several rivers in opposite directions, (a metaphorical figure to indicate the point of their divergence) was not admitted, upon MOORCROFT'S assertion, to be land-locked, from ideas of the feebleness of evaporation at that great height then unknown and unsuspected ;* and though the lake does appear to have an outlet in the *Satlej*, this does not alter the question in regard to basins (inferior it is true to *Mánsarovara*, but under similar circumstances) having been found wholly inclosed ; and MOORCROFT was right as to the fact, though his reviewers could not reconcile it with their preconceived opinions. *Chamorerîl* (which is probably fifty miles in circuit) has no passage outward, though it is fed by streams which have a broad channel, and run with great volume in their season. † Evaporation by an atmosphere which from its extreme rarity and dryness, greedily drinks up moisture, is here amply sufficient to graduate the marginal limit of those lofty reservoirs to the extent of four or five feet, which was the maximum fluctuation that Moorcroft observed, and I myself have found to prevail. The hot winds are even there far less parching than the air of the interior *Himálaya* in autumn,—wood, books and shoes warping under it. At *Shipke*, upon the verge of the table land, this dryness was quite withering, and every thing flexible was converted into a coriacious hardness, and we felt a sensation of intense cold when the thermometer pointed between 40° and 50°, and, under the influence of a strong wind, the effect of a temperature but a few degrees lower was quite benumbing. In the British territory of *Kunáwer*, laying beyond the *Himálaya*, all the fruits are dried upon the tops of the houses at the season of the periodical rains in India. Even turnips are preserved in this way. To this state of the climate is owing the superiority and preservation of all the northern fruits of *Kashmír*, *Kábul*, and *Kandahár*. A circumstance still more surprising in this atmospheric vicissitude upon the immediate verge of an Indian sky, came under my own observation. The fresh roots of the *Rheum palmatum* which I dug up from amongst patches of snow at the solstice in the *Himálaya* ridge, were so brittle in August as to be easily reduced to powder, and moist opium received in *Kunáwer* in the middle of July, was pulverised to an impalpable fineness in the subsequent month,—thus at the most humid period of the year was effected a process that in India is

---

* The table land of *Thibet* was estimated by European theorists, at eight thousand feet above the sea, though Captain TURNER had shewn the unprecedented rigors of the climate even in so low a latitude, and MOORCROFT'S Narrative had given us a sufficiently frightful idea of midsummer in that country.

† This lake occurs in *Rupshú* at an elevation of fifteen thousand feet. It is a long sheet of blue water with a varying breadth. My route took me by its margin for a whole day's journey, and I encamped at its eastern extremity where the shore was of turf. No water mark appeared above five feet, and as I was here in the end of September, that may be considered as the limit of fluctuation, a circumstance which was assumed by theorists in regard to *Mánsarovara* as proving the reverse of what Mr. MOORCROFT asserted, or that there must bé a drain from the waters of the lake. *Chumoreríl* has likewise no efflux, though several streams pour the liquified snow of the neighbouring mountains into its basin. Evaporation in this dry air is fully sufficient to preserve the balance, and it is more surprising that any water should remain at all, than that no outward communication should exist. The northern margin of the lake is hemmed in by a mass of mountain which shoots up in a nearly mural precipice of bare rock to a height of twenty thousand feet and upwards. The snow rested close to the summit, but in vast bodies, having a cliff of several hundred feet, and but for its dazzling whiteness might have been confounded with the rock itself. It had ceased to melt. In winter the lake freezes, and remains fixed for several months, the snow then accumulates upon the ice and

---

with the return of spring the gelid expanse breaks up with a noise like thunder, and thaws away, and torrents from the surrounding high land contribute their accessions and rise the surface to its maximum limit. Evaporation now exerts the combined influence of an ardent sunshine and a dry attenuated atmosphere, and by the end of August the lake has sunk to its greatest depression. *Mánsarovara* is precisely similar, but upon a much larger scale in respect to the volume of its waters, its elevation and magnitude of the scenes around it. The water is well tasted, which would seem to argue some outlet, which the oral accounts of the *Lámás* would confirm to be that of the *Satlej*;—as to the egress of any other river in such a situation,—it is a supposition bordering so closely upon a physical impossibility that it need not be entertained. The waters of *Lake Chamoreril* (as might be expected from their having no drain) are unfit to drink, though barely differing in taste from that of running streams. Another lake, two days journey west of *Chamoreril*, at an elevation of fifteen thousand five hundred feet, was found very bitter and brackish, and I was surprised to see wells of the finest water, in the very midst of the salt marshes: innumerable wild fowl covered the entire surface.

scarcely attainable by any length of time, while in Calcutta opium cannot be dried for medical purposes without artificial heat. In Europe the rhubarb roots, at the end of a year, generally require to be baked in an oven before they can be pulverized.

Hygrometrical considerations seem to have been entirely neglected by travellers in India. I was fortunate enough in being put in possession of KATER's hygrometer, in the tour I made to the sources of the *Hyphasis* and *Chunáb*, and across the high land of *Rúpshú* into *Spíti*, which afforded me an opportunity of comparing the state of the air on both sides of the *Himálaya*, and the degree of humidity that belonged to different elevations and situations; the general conclusions from which were, that the atmosphere of the interior regions was more than twice as dry as that which rested upon the southern hills;—that the aspect of vegetation and the rocks corresponded with the indications of the hygrometer, and that the climate of the valley of *Spíti* at an elevation of between twelve and thirteen thousand feet, in October, was infinitely more arid than that of *Subáthú* at four thousand feet, in May and June, when the wind becomes heated and the country parched up. The temperature in the former was between 40° and 45°;—in the latter 80° The minimum of the hygrometer, in a scale that indicated 1,200, as the point of saturation was 038,* the barometer being then 19.270, thermometer 53°. For a succession of days the range varied between .042* and .055* for the least, and 170 to 190 the greatest, which last always occurred sometime after sunrise†. At elevations of nearly fifteen thousand feet, the results were not so decisive owing to the presence of clouds in the air and to the great difference of temperature, the correction for which I have never ascertained.—In these last situations the weather was very cold and unsettled, the thermometer varying from 12° to 41°, with occasional sprinklings of snow. Under analogous conditions the dryness of the air increases with the elevation. I regret having overlooked the wet bulb thermometer which from its principle and simplicity is, without a doubt, the most correct measure of atmospherical humidity: a compensation may however be suggested for the effect of the wind in accelerating absorption.

---

* So written in the MS.; perhaps intended for 38, 42 and 55.

† At *Subáthu*, KATER's hygrometer seldom fell under 100 in a temperature exceeding 90°.—In *Spíti*, in October, the depression was generally 45 in an atmosphere of 50 degrees.

The face of the country, as far as it has been seen, affords a desolate view to the botanist, but the field is not so unproductive as it looks, and vegetation though scanty, will be found to exhibit many new species and peculiarities. A generic character prevails: most of the plants being armed with spiculæ: furze and spartium form the general clothing of the soil. In animal nature, the scene is equally fertile in variety: and in geology, there is much to interest inquiry; and if elevation is an object of science, the mountain ranges here offer facilities of ascent, which the steepness of the southward *Himálaya*, the snow and the cloudy climate, entirely oppose. It is obvious that angles taken from an altitude of twenty-one thousand feet, would be subject to little or no refraction where the visual ray passes through so thin a medium. From such a position, the highest levels of the country would be accurately indicated, assuming the base to be correct, which barometrical observations would sufficiently establish. Objects visible upon the plane of the horizon, at a distance of one geographical degree, would be actually elevated three thousand feet: the extreme height of the mountain range would thus be readily determined, as the observations would be liable to little discrepancy from atmospheric causes. The climate in summer is sufficiently favorable for a stationary residence, and at twenty thousand feet, one would rarely be exposed to a severer night temperature than 20°, or during the day, to one of ten below 45°, very commonly much higher, from the power of the sun's rays. Observations might be made on the diminished pressure of the air upon the organs of life and matter, evaporation, and many meteorological phenomena.

The hope of new discovery increases the feeling of gratification we experience in treading over spots unvisited by man. No precious ores have yet come to light, but if analogy is any guide to expectation there is nothing against the supposition, that metallic riches may be concealed in the lofty masses of the interior, which in configuration and structure, correspond to those that produce them in America. This is not a new conjecture, and if they do exist, their site will probably be found in the highest zones of the limestone or clay slate. The lenticular particles of gold which are daily washed from the sand of the *Satlej* and other rivers, afford no clue to the solution of the problem, but together with the conformation of the mountains and the fact (orally related) of auriferous ores having been discovered in *Thibet*, there is no reason to discard the idea. Copper has already been found at *Súngnam* in *Kúnáwer* and in *Spíti*; which is here at least as presumptive of the existence of precious metals as galena is of their mines upon the hither side of the *Himálaya*, which though discovered, seem doomed to oblivion through the timidity and poverty of the chiefs of the soil.

It is to the inner ranges that we must direct research for the germs of metallic wealth, and especially where the great lines of level mark the highest continuity of the country. There is nothing to expect from the primitive formations which shoot up in hard compact masses into the peaks recognised from the plains of *India* as the *Himálaya*.

In the mountains verging on the table land, the rocks are all of the order considered as secondary and of the very class which envelope the treasures in the Andes. In those formations we have in a general view horizontal sandstone, wacke clay, and micaceous slate, and varieties of limestone, even down to the transition structure that displays itself in caverns, stalactites, &c. &c. and contains animal remains and traces of plants, being often entirely composed of vegetable matter. The soil itself appears in argillaceous earth, beds of gravel, clay, and marle, deposits of gypsum, and a cineritious looking rubble, indicating coal or plumbago. Though no traces of ore are visible upon the surface, those mountains may only differ from the American chain in containing it in the loftiest zone, untrodden by man; but the mineral state of the interior has not yet been examined, and neither the scenes of savage beauty in some places, not the grandeur of their barrenness in others, have urged adventure to explore scientifically their lofty strata. The fossils of the *Himálaya* in respect to variety, extent, and elevation, are amongst the most curious objects to the naturalist, who sees here the great mass of secondary formations, and even portions of the table land itself, rising higher than the primeval peaks. This is sufficiently remarkable in the lofty level of *Rúpshú* between *Ladák* and *Spíti*, and the still higher belt of country intersected by the *Satlej* between the Chinese frontier at *Shipke* and lake *Mansarovara*, supported by the *Himálaya* on the south, and flanked by the great *Kylas* or *Laochi* chain washed on its nortward base by the Indus, beyond which all our knowledge ceases; but information, and conclusions together vague and unprecise as they are, hold out the ground and idea of still loftier ranges, the nature and limits of which we cannot even conjecture. The eternal snows are there repelled to an incredible height, resting partially or entirely vanishing, from the face of the country, very little being here precipitated from skies almost bare of clouds. The rounder and more lumpy configuration of the mountains and gentler undulations of the soil would seem to indicate their structure to be analogous to that of the regions which have come under observation, and the accounts of the *Lamas* confirm the report of calcareous deposits, gravel, clayish, or *kankar*, rubble, and alluvial formations, wherein shells and various organic remains, with petrified bones, are found intermixed with decomposed felspar and the fossil exuviæ of animal matter. From the vast extent of the homogeneous tract, as inferred from the narratives of travellers and the productions of distant points of the plateaux, there is every probability that the whole country lying at the back of the *Himálaya*, the mountain ridges and plains of the interior from the skirt of *Ladák*, and even the limit of *Túrkistán* to the table land of the *Brahmaputra* at *Teshú Lúmpú*, abound with fossil relics, the living prototypes of which have disappeared from the earth. The grounds of this belief are not comprised in the productions of the *Spíti* valley; several of the most curious shells having been obtained from remote parts of the interior, but not being objects of appreciation by the people as the *Salagráma* stones are in India, they pass unregarded, or are viewed with superstitious reverence as in the case of the fossil bones of the *Mammoth*, considered to have fallen from the clouds. The very few shells which have thus come to light, are chiefly interesting as insulated specimens of the varied resources of the country; being from their unknown situs and position deprived of their value to the geologist, though still identifying the continuity of character, and pointing out an intimate analogy with the fossil geology of opposite regions of the globe.

The valley of *Spíti*, though remarkable for the poverty of its soil and inhabitants, claims consideration in a physical view, the river rolling over a plane, the extremities of which have a difference of level exceeding one mile in a distance of one hundred, a fall unindicated by the appearance of the stream. The declivity is to the south east, and the course so nearly parallel, that with the exception of a single deflection above *Sheealkar*, a straight line would almost lie within the whole channel, a feature in perfect conformity with the homogenous nature of the rocks through which it passes; and wherever an obtrusive formation occurs there the velocity of the stream undergoes a change, all the harder or primitive rocks which enter into the structure of the channel uniformly hastening the slope, giving the river an impetus, which often roughens to a torrent.[*] In the secondary or softer strata, the channel is less jogged and the surface of the stream smoother, and where the district is limestone, gravelly, or argillaceous, it meanders silently, threading its way in the sand by numerous intersections: a corresponding character is imprinted on the landscape, the mountains betraying their structure in their configuration. The lower region of the dell is very rugged and abrupt, the granite rocks on each side at the conflux with the *Satlej* cut into mural precipices, hang like vast gates over the slowly emerging river. The eastern wall of this chasm runs up with an unequal slope till it is crowned by the sharp cliffs of *Parkyúl*, bordering upon twenty-three thousand feet, and repelling the snow from their arid sides to within three thousand feet of their summits.[*] With the exception of a few miles at the embouchure, the river upwards, as far as the village of *Chango*, is much inclined, appearing in a line of whiteness. In this neighbourhood, especially at *Shialkar*, the mountains exhibit their sides of rotten argillaceous slate, and at their bases we see tumuli of loam like potter's clay protruding through the black soil. The eternal snow (summer line) here recedes to nearly twenty thousand five hundred feet, on a south western exposure, the bottom of the valley being itself ten thousand feet above the sea, but the effect of solar radiation in this arid concave modifies a climate, which, in insulated elevation would be unproductive of grain, to a temperature capable of rearing consecutive crops in the proper season.

---

[*] Two of the peaks have been found by measurement, respectively, twenty-two thousand five hundred and twenty-two thousand seven hundred, but it is probable that there are still loftier points in the back ground where it abuts upon the table land. The ridge trends along the *Spiti* as far as *Chango*, where it is deflected to the north east, and softens into vast heaps. being no longer peaked, and the granite evidently running into the secondary class of rocks, and giving the bluff contour to the masses which have a waving gravelly appearance, with a regular slope. Then summits which seem to exceed twenty-one thousand feet are forsaken by the snow. Even after a heavy fall in the beginning of November which covered the face of the country—those arid mountains presented the lightest drapery like hair powder. My lofty position above the cottage of *Changrezing* was upon the slope of one of those enormous heaps, and they extended towards the chain of red peaks with an ascending elevation.

In a notice by Mr. Colebrooke in some English publication, upon the comparative results of various measurements in the *Himálaya* regions, made by Captains Herbert and Gerard, he remarks that the only great difference between the observations of the two Surveyors occurred in the altitude of *Parkyul*, where this amounted to three thousand feet, which is a mistake either on the part of Mr. C. or in the statement of the case. The station upon the slope of *Parkyul*, at nineteen thousand five hundred feet, being confounded with the crest of the peak which is twenty-two thousand five hundred feet, a discrepancy of sufficient magnitude to lessen the dependence to be placed upon the accuracy of all the results.

Upwards from *Sheealkar*, the river has a slower acclivity. The marginal rocks crumbling at their surface terminate in smooth slopes of finely comminuted matter, and finally in steep dead sand, which repels both vegetation and snow, till near ***Dánkar***, where the valley making a sharp flexure, resumes its natural direction, deriving a new feature from the transition of the rocks which now mark the fossil district, and open out at their base to a flat pebbly expanse of three furlongs.

The scene now begins to wear a desolate grandeur; every object is arid, the parched and thirsty soil ceases to shew a glimpse of verdure. The river winds its course in streamlets through a bed of sand and pebbles. The section of the rock being very steep exposes the stratification, which is here slightly inclined from the horizon. ***Dáukar*** itself is perched upon a projecting ledge of conglomerate limestone, rising out of the valley in steep indurated masses, which the erosion of time has filed into slender spires and the percolation of snow eaten away at their bases till they present a groupe of turrets and ravines almost deceiving the senses by the effect of natural agents. These lofty piles have a compact solidity which resists the hammer. Their sides are often scooped into places of abode, and the natural excavations are taken possession of by monks and a vagrant priesthood, who detaching themselves from the rest of the world like the Druids of old, are to be seen peeping out from their isolated niches.

The valley beyond this point preserves a considerable expanse, varying with the structure of the mountains, which sometimes jut out in hard black masses, contracting the river, but the bed continues pebbly and unhampered by rocks. The near cliffs on each side rise to about sixteen thousand feet, and are entirely bare, the snow resting at twenty thousand feet upon southern aspects, and except in hollows, not greatly lower on shaded sides.

At the village of *Rangrít*, two days journey about *Dánḳar*, the bason of the river has a fine spread, and is here intersected by sandy islets, bearing Tamarisk bushes and a turfy vegetation, whereon the flocks feed in winter by scraping through the snow. The country has the same arid complexion, and encroaching barrenness alone marks the course of the valley, while gleams of the snowy frontier of *Rúpshú* are seen through the defiles of torrents, and a sharper section of the mountains foretells approach to its recesses. The cultivable step is greatest upon the right bank, the cliff of which, on both sides, from one to two hundred feet high, is worn into pillars like gigantic minarets. Their composition is an aggregate of gravel, pebbles, or calcareous rubble; the left alluvial sediment of the river baked to a rugged hardness by the sun's rays, and tapering into cones which are frequently crowned by a flat stone like an entablature; their bases eaten away till they fall within the perpendicular, and altogether so frail as to appear to the spectator who passes them, an impending danger which hastens on his steps; yet they stand erect, crumbling only at their surface, and, subsiding imperceptibly to the surrounding level, vanish amidst their own ruins, from which others again take their rise, and in their slow formation and slower decay, they record long periods of time being the last remains of a bank or entire section that has thus worn away. These groupes of tumuli which are often left insulated upon the steepest slopes of the mountains, where all around is uniformly smooth and bare of vegetation, are viewed with timid curiosity by the traveller, who descries them from afar through the loaming air like fortified castles, but here man is not his enemy.

At this point of the valley the river has an actual elevation of twelve thousand feet, and the narrow inhabited slip, from two to four hundred feet higher, trends on each side with a steep cliff to the stream, backed up by the bases of the mountains which here assume a perpendicular form, and the gradual erosion of their surface has thrown up heaps of finely attrited matter that reaches high upon the sides of the rock no longer visible, and in the course of time will overtop the loftiest peaks, and the whole country be thus buried in its own dust by a process of nature, which, however slow, is inevitable and irresistible.

The rise of the level continues beyond *Rangrík*, at the rate of thirty feet a mile; the river winding with a varying expanse and making sharper flexures; the rocks of a packed structure assume a bolder and more lumpy form, their inward faces steep and scabrous, terminate in flat summits, or are deflected in a slanting plane at a medium height between sixteen and seventeen thousand feet, a limit which is occasionally whitened by snow at mid summer. These are but the cheeks of the river, and the roots of a parent chain on each side which towers majestically in the back ground. The villages of *Hayl* and *Hansí* rest at an elevation between twelve and thirteen thousand feet: here the river is still of considerable volume, but fordable with some exertion; and at *Lossur*, the last inhabited spot, a few miles higher, the stream was found so much reduced that I crossed it with ease upon a man's back in the month of August, but the width of its bed argued its much greater size at an antecedent period of the year. Beyond *Lossur* the river has not been traced. On coming down upon the village from the heads of the *Chunáb*, I found its bed, at a spot nearly a mile higher, to have an elevation approaching to thirteen thousand five hundred feet, and the slow rise of the river onwards, as shewn by the flatness of the channel and creeping progress of the stream, indicated the forks to be still at some distance, and the valley, before it breaks into a gorge, to have a vast altitude, perhaps not under seventeen thousand feet. The nature of the country at *Lossur* partakes of the general arid display. The mountains are more continuous, and throw out their cliffs like a wall, where neither snow nor soil can rest; their tabular summits adding a new feature to a scene of calm desolate grandeur.

In August the crops were still green and the morning temperature at 42° The village occupies a slip of soil at the feet of the mountains, and cultivation descends in a slope graduated for irrigation. The people are even darker here than in the lower and warmer regions, and when the ground is covered with snow the black figures moving into sight have a very grotesque appearance, as they glide along the sheeted surface to which they form so sad a contrast. Mankind here, like plants in other climes, groupe together for mutual comfort and protection against the pressure of the climate. Lofty as the level of *Lossur* is, there is little in the landscape to betray its position when viewed in summer embosomed in flourishing crops and herds of shawl-wool goats. Yaks and horses meet the eye upon the high acclivities of the mountains, and an ardent sunshine keeps the air loaming from the effect of mirage. The *Spiti* below in its smooth sandy bason might even be recognised as a stream in the plains of *India*.

I had no opportunity of obtaining precise information about the remainder of the river, much less of following it up; but from the conformation of the channel and glance along the stream, while I stood in its bed. I have no doubt that it penetrates several days journey beyond *Lossur*, and that it forms the base of direction to a pass into *Rúpshú*, which by inferences from another, at a lower point of the valley, may be concluded to be upon the verge of nineteen thousand feet, and as the streams from that elevated level still flow by a circuitous course into *Spití*, (none finding a slope to the *Indus*) there is the most presumptive proof for the supposition of higher ranges in the area included between that river and the *Satlej* than has yet been observed in the detached cliffs of the *Himálaya*, which seen from spots little elevated above the sea, in sharp towering peaks, impress by their imposing portraiture an idea of greater altitude than that which is recognised in the mountains behind them, where this effect is absorbed in the vast elevation of the soil from which they rise, and the very lofty position of the spectator who views them. The mountains upon the Tartaric frontier derive from the elements of their formation a rounder contour, appearing like gigantic sand heaps We here behold them as it were planted upon a plain, which is itself more than half their entire height. The stream of the *Satlej* at *Shipke* has already risen to nearly ten thousand feet, and at *Bekhar*, thirty miles farther, it approaches to eleven thousand. At the town of *Daba*, under *Niti* pass, and eight days journey from *Mansarovara* it verges upon fifteen thousand; limits which, if in insulated elevation, would of themselves be considered as very lofty, are here lost in the continuity of the neighbouring surface, and the highest ridges are apparently diminutive, and where the lines of level reach a greater altitude the inequalities of the soil become quite insignificant. In the plains and vallies of *Rúpshú* I found myself surrounded by black conical hills of from three to four thousand feet, mere heaps, yet they had a positive height of twenty thousand, the flat expanse at their base being here sixteen thousand. Lake *Chamorerîl*, the greatest depression of the soil was still fifteen thousand feet above the sea, while Lake *Mansarovara*, from conclusions grounded upon barometrical observations made in the course of the *Satlej*, appears to be at least seventeen thousand. It is not surprising then that the country of the *Oondes*, or *Hun-dès*, seemed to MOORCROFT to be less lofty than the *Himálaya*, and that even *Kylás*, so conspicuous an object of reverence and superstition, elicited no mark of admiration when seen from a position so elevated, that *Chimborazo* itself would look like a mole hill, and the highest summits of the *Himálaya* cease to appear majestic. Subsequent travellers have been equally deceived by the aspect of the interior, and though aware of their own elevation, erred prodigiously in their conclusions on the height of the country. Seeing the mountains under a less abrupt form, and only capped with snow produced a conviction of their depressed altitude, and that the whole surface had a downward tendency; a knowledge of the reverse may be now safely hazarded even upon the rude approximations which have been obtained. A traveller in *Rúpshú* finds himself, for days together, upon a level between fifteen and seventeen thousand feet, which runs in flat slips, or slightly inclined valleys, formed by the intersections of the mountains which are crossed at their depression, between eighteen and nineteen thousand feet; but this broken land already borders upon *Ladák* and the *Indus*, the bed of which under *Leh*, the capital, has probably an elevation exceeding eleven thousand feet, yet the country all around was very high, and the distant mountains in sight not only uniformly white in a region where the perennial snows rest beyond twenty thousand feet, but this belt was very broad, and the aspect was more that of mountains of snow than snowy mountains, my own elevation being here eighteen thousand feet; circumstances of themselves arguing vast height and removing at least much of the uncertainty and many of the errors which the consideration of such a subject would involve under the usual elements of the problem.*

---

* Barometrical results from their extreme simplicity and facility of observation, have not received due estimation in Geometrical operations, while inaccuracy in the instruments or observers have justly depreciated their value. It will however be found that with the correctness of which they are susceptible, their indications will approximate so closely to Trigonometrical measurements as to leave the question of superiority doubtful. I allude here to those Mathematical operations, which, by their conditions, exclude every source of error arising from refraction or the determination of the base and angles of the triangle: in cases of considerable difference in which the triangulation involves long distances, and in instances where two of the angles can only be observed, barometrical conclusions deserve the preference, and in almost all are indispensable adjuncts, and afford satisfactory verifications, while the most interesting portion of Physical Geography, the lines of level which

The idea of other and still loftier ranges beyond those gelid scenes, extending along the southern skirt of the *Indus*, is strengthened by the information of the goatherds upon the spot; but those observed from a barometric level of 15.520, answering to eighteen thousand feet, where the

---

regulate climate and vegetation, the sections of river courses and the planes of water communication throughout a country admit of no other method. On comparing the circumstances which affect the conditions of the respective operations, we shall see that the refractive power of the atmosphere involves a source of error of infinitely greater extent and uncertainty than the variations in its gravity which almost alone enter into Barometrical computations, and can be compensated by the medium of a large range of simultaneous observations. In cases of small angles at great distances the uncertainty of refraction must always prevail, and in the various degrees of temperature and humidity of the medium through which a ray of light passes from an object in the *Himálaya* to the eye of an observer upon the plain of India, if the angle is less than 1°, the undeterminable quantity might be sufficient to vitiate the whole calculation, if this is made with reference to a fixed point, but without assuming the extreme limits of error which are liable to result from the deflection of the visual ray in an atmosphere, varying in temperature within the points of observations to 70 or 80 degrees, the uncertainty still remains as to the quantity to be allowed for the intercepted arc, in cases where the three angles of the triangle cannot be observed, which include all the grand points of the chain, and for which allowance there is no precise measure, and a mean from the extremes only reduces the height of an object within the limits of a very considerable space, in many cases exceeding a thousand feet. With respect to Barometrical heights, much superfluous objection has been made in regard to the variations in the specific gravity of the mercury arising from natural impurities or adulteration, but which are notwithstanding, limited to a mere imaginary compass, from the impossibility of alloying the metal to any appreciable extent, without rendering it useless for the purpose. These are however, determinable errors, which may be destroyed entirely. In the dry and brilliant regions which have disclosed the scenes of gigantic grandeur alluded to, refraction becomes a computable element; from stations elevated eighteen and nineteen thousand feet, the angles of the most distant objects would be subject to little derangement from variation in the density of the atmosphere and vertical bases which are generally within our reach, by their proximity to each other, would prevent the accumulation of error by reducing the interval between the observation of the angles to an almost cotemporary result; another advantage occurs in Barometrical levels at very lofty stations in the slight changes of atmospheric density, or at least the uniformity of the fluctuations. It is true that it requires but half the extent of the oscillations in the mercurial column here, to produce the same effect (error) as at the level of the sea, but this is equally appreciable at the highest as at the lowest regions, and the discrepancy (whatever this may be in an altitude of four or five thousand feet, is not liable to be augmented in that of eighteen or twenty thousand, a correction for the hygrometric state of the air seems still a desideratum in Barometrical calculations. Under all the circumstances of the measurement when made with accuracy and the necessary compensations, we may safely night temperature was 13° on the 23rd September, had a sufficient angle to approximate their altitude to twenty-five thousand feet, and this not in a few detached points but a continuous line of peaks, while the paler snows which encircled the summits of the most distant, indicated them to be still loftier, and without assigning them the extreme height, (in that of

---

assign two hundred feet for the maximum limit of error in the greatest altitudes, and at the most remote distances from the site of cotemporary observations, a quantity not so great as results between separate Geometric operations by the same person or between different observers, and even less than the difference in the computations of separate individuals from the same premises, and infinitely less than the limits within which refraction varies in the ordinary state of the air. An application of the argument is found in the *Chúr*, an insulated mountain ridge, twelve thousand one hundred and forty-seven feet high, in the hill state of *Tirmúr*, north of *Náhn* and *Saháránpur*, chosen as the grand Trigonometrical station for the survey of the country between the rivers *Satlej* and *Jamna*, and its altitude fixed by a series of simultaneous observations made under different circumstances of seasons and temperature upon its summit, and *Saháránpur* upon the plain at an oblique distance of about fifty miles. This being an accessible spot, all the angles of the triangulation were observed and the amount of refraction determined, the greatest accuracy is therefore due to the operations. Several years after, I visited the spot on the day of the summer solstice, at the commencement of the rainy season, when the difference of temperature between the peak and the plains was about fifty Thermometrical degrees and the atmosphere variable. The Barometers I used were constructed by myself upon the spot. The tubes, though under twenty-eight inches, exhibited a perfect vacuum, the mercury having been boiled within them. The scale was a fir rod, the horary observations were made at my camp seventy feet below the summit, and several were taken upon the extreme point of the peak, the result of the whole as calculated from simultaneous observations at *Subathú* the height of which was fixed, came within three feet of that deduced by the most accurate operations of trigonometry which is perhaps proving too much. A subsequent measurement, at an interval of some years, and computed from Barometrical observations at Calcutta, was within a few feet of the same result. The uniformity in Barometrical indications proves their accuracy. Far loftier spots than the *Chúr* have been visited at different seasons of the year, and with different Barometers with the most satisfactory results. The passes in the *Himálaya* at fifteen and sixteen thousand feet, in the midst of eternal snow. Those upon the verge of the table land at elevations of eighteen thousand feet, in a bleak arid country, and stations upon *Farkyúl* at nineteen thousand five hundred feet, and the difference in the respective heights seldom approached to one hundred feet, though the temperature under which the observations were made sometimes varied forty degrees. Upon every consideration then, the Barometrical levels taken in my journey to the skirts of *Ladák*, and at various times upon the frontier of the Chinese territories, may be depended upon as true indications, though I have not attempted to reduce them to measurement, but contented myself with general conclusions, in round numbers, as more consistent with the nature of the subject.

a solitary peak,) there is ample room to confirm their rivalry over the southward *Himálaya.*[*]

The snowy chain, west of the *Ganges*, is crossed at elevations of between fifteen and seventeen thousand feet, and rarely the latter. At the sources of the *Hyphasis* in *Kúlú*, the depression of the *Himálaya*, at the pass of *Rotang*, is as low as thirteen thousand feet, but the northern ramifications of the chain are traversed in an ascending series in that of the *Paralassa* and *Laítche*, long ridges, respectively sixteen thousand five hundred and seventeen thousand feet; a third which formed my nearest appulse to *Ladák*, was approached by a valley itself elevated sixteen thousand feet, and from the steepness of the slope in its winding course beyond my position, I concluded the pass in the range to border upon eighteen thousand feet. The contiguous peaks, at a far higher level, were perfectly black in the middle of September,—but before reaching *Ladák*, another range, the *Parang Lá*, is crossed, which being sheeted in snow, and the passage expressly described as attended with laborious respiration, debility, and the usual effects of a highly rarified atmosphere, we may infer to be still more lofty.[†] This chain runs upon the limit of the *Indus*, and is no doubt continuous with the line of cliffs already noticed, which appears to stretch away uninterruptedly to the forks of the river near *Mansarovara*. Pursuing the analogy, by going eastward, the passes to night temperature was 13° on the 23rd September, had a sufficient angle to approximate their altitude to twenty-five thousand feet, and this not in a few detached points but a continuous line of peaks, while the paler snows which encircled the summits of the most distant, indicated them to be still loftier, and without assigning them the extreme height, (in that of

---

[*] This measurement excludes the still loftier limits which have been assigned to *Dhawalgiri*, *Chamalári*, and other peaks in the south-eastern quarter of the chain which have not afforded the same advantages of verification, and may still be considered as desiderata. A few others have indeed been determined at twenty-three and twenty-four thousand feet, but even those detached points can scarcely be taken as a measure of the magnitude of the range as compared with the vaster continuity of the interior ridges of the table land.

[†] There is some uncertainty whether this range of mountains is crossed by the route I followed, but it exists and is represented as a very formidable barrier. My nearest appulse to *Leh*, the capital, appears to have been still five days' journey distant, which allows ample space for the intervention of the snowy ridge of *Parang Lá*.

---

assign two hundred feet for the maximum limit of error in the greatest altitudes, and at the most remote distances from the site of cotemporary observations, a quantity not so great as results between separate Geometric operations by the same person or between different observers, and even less than the difference in the computations of separate individuals from the same premises, and infinitely less than the limits within which refraction varies in the ordinary state of the air. An application of the argument is found in the *Chúr*, an insulated mountain ridge, twelve thousand one hundred and forty-seven feet high, in the hill state of *Tirmúr*, north of *Náhn* and *Saháránpur*, chosen as the grand Trigonometrical station for the survey of the country between the rivers *Satlej* and *Jamna*, and its altitude fixed by a series of simultaneous observations made under different circumstances of seasons and temperature upon its summit, and *Saháránpur* upon the plain at an oblique distance of about fifty miles. This being an accessible spot, all the angles of the triangulation were observed and the amount of refraction determined, the greatest accuracy is therefore due to the operations. Several years after, I visited the spot on the day of the summer solstice, at the commencement of the rainy season, when the difference of temperature between the peak and the plains was about fifty Thermometrical degrees and the atmosphere variable. The Barometers I used were constructed by myself upon the spot. The tubes, though under twenty-eight inches, exhibited a perfect vacuum, the mercury having been boiled within them. The scale was a fir rod, the horary observations were made at my camp seventy feet below the summit, and several were taken upon the extreme point of the peak, the result of the whole as calculated from simultaneous observations at *Subathú* the height of which was fixed, came within three feet of that deduced by the most accurate operations of trigonometry which is perhaps proving too much. A subsequent measurement, at an interval of some years, and computed from Barometrical observations at Calcutta, was within a few feet of the same result. The uniformity in Barometrical indications proves their accuracy. Far loftier spots than the *Chúr* have been visited at different seasons of the year, and with different Barometers with the most satisfactory results. The passes in the *Himálaya* at fifteen and sixteen thousand feet, in the midst of eternal snow. Those upon the verge of the table land at elevations of eighteen thousand feet, in a bleak arid country, and stations upon *Farkyúl* at nineteen thousand five hundred feet, and the difference in the respective heights seldom approached to one hundred feet, though the temperature under which the observations were made sometimes varied forty degrees. Upon every consideration then, the Barometrical levels taken in my journey to the skirts of *Ladák*, and at various times upon the frontier of the Chinese territories, may be depended upon as true indications, though I have not attempted to reduce them to measurement, but contented myself with general conclusions, in round numbers, as more consistent with the nature of the subject.

actually picked up some of the shells was on the crest of a pass elevated 17,000 feet, where also were seen numerous blocks of the calcareo-silicious matrix. I was not able to pass more than a single day at this interesting spot, but I brought away numerous fragments of the rock. If the observation of shells and mountain strata of organic remains at such an altitude be worthy of attention to the geologist, I am happy in having enjoyed the opportunity of verifying the fact—leaving to more experienced hands the recognition of the species and the age of the fossils, the classification of the strata in which they are imbedded, and the theory of their being raised to their present elevation.

NOTE.

It will be seen by the heading of this paper, that it contains only the "first part" of Dr. GERARD's observations on *Spítí*, and treats of the geography, elevation, and climate of the valley; the second part, which was to have described more particularly the geological features of the country, in illustration of the fossils presented by the author to the Society, has been delayed by Dr. GERARD's journey to the *Oxus*, and cannot now arrive in time for insertion in the present volume: the last paragraph has therefore been added from information contained in the author's letters to the Society accompanying the specimens. It may also be convenient to notice here that duplicates of many of the shells described in the Rev. R. EVEREST's memorandum, page 107, were sent at that gentleman's request to Mr. SOWERBY, author of the "Mineral Conchology," the substance of whose reply is here subjoined, with alteration of the numbers, that they may coincide with the figures of the plates of Mr. Everest's paper.

Extract from Mr. J. D. C. Sowerby's letter to Mr. James Prinsep, Sec. Ph. Cl.

"I had before seen some specimens from the same mountains in the possession of Mr. STOKES and Dr. BUCKLAND, among which were several ammonites that are as yet unnamed. The Rev. Mr. EVEREST's deductions are correct as far as they relate to the formations the fossils belong to, as will be seen by the accompanying list of names, to each of which I have added the formation in which that species occurs in England. In the genus *Terebratula* there are many species that cannot be depended upon as indicating particular formations, because very similar ones are found in several beds, and the species are difficult to determine, especially if not quite perfect. The *Pecten* mentioned as resembling the common scallop (of which no specimen was sent home) is probably the *P. æquivalvis*, which is characteristic of the inferior oolite; the *Helix* mentioned also may possibly be *Ampullaria nobilis* which accompanies the *Cirrus* in the lower beds of the mountain limestone of England and Ireland."

5, Camden Terrace, 14th October.

List of Himálayan Fossil Shells.

Pl. I, Figs. 2, 3, 5—*Ammonites annulatus, anguinus* of Schlotheim, Zeiten Versteinerungen Würtembergs;—*t.* ix. f. 2. Min. Con. tab. ccxxii. fig. 5 is the same shell:—Lias formation. The large specimen is filled with sulphate of barytes.

16—*Belemnites sulcatus* Sillot, Miller, (Trans. Geol. Soc., 2d series, vol. II, pt. I, pl. 8, fig. 3 4, and 5.) *Bel. apicicomus*, Blainville's Memoire. Lias, inferior oolite.

15—*Alveolus* of a Belemnite, perhaps of *B. sulcatus.*—*Orthocera conica* of Min. Con. tab. ix, although called an orthocera, is only an *alveolus* similar to this.

Pl. II, Fig. 19—*Avicula* (rather than *pecten*), new species.

22, 23—*Spirifer striatus.* (Min. Con. tab. cclxx.) Mountain limestone.

25—Cast of the interior of the same shell.

24—*Producta scabricula.* (Min. Con. t. lxix. fig. 1.) This and the *Spirifer* are in a stone strongly resembling some of the Transition slate of England.

26—*Astarte plancta*, var. (Min. Con. tab. cclvii.) Inferior oolite. A variety of this shell is found at Bayeux in Normandy, and is called *Crassina modiolaris.*

28—*Nucula*, an unnamed species; similar fossils occur in the mountain lime and lias.

29—strongly resembles a portion of some large *Inoceramus*, but is not perfect enough to determine."

Of the other shells depicted in the plates, there were at that time no duplicates for transmission to England. The shells in Plate III, are for the same reason unnamed.

J. P.

XVI.

NOTE
ON THE
DISCOVERY OF PLATINA IN AVA.

By JAMES PRINSEP, F.R.S., *Sec. Ph. Cl.*

THE first suspicion of the existence of Platina in the Gold Dust of *Ava*, occurred to Mr. CHARLES LANE, a merchant residing at the Burmese capital, *Amerapúra*, in 1830. That gentleman transmitted through Major BURNEY, the Resident, a small button of the suspected metal, along with other minerals, to Mr. GEORGE SWINTON, who presented them to the Asiatic Society on the 15th January, 1831.

A Note on the examination of this button was published by myself in the GLEANINGS IN SCIENCE for the following month, in which it was shewn that the metallic bead was a fused alloy of platina, gold and iridium, with iron, arsenic and lead. It had a specific gravity of 17.2, and was fusible at a forge heat into a round button. At a temperature of 1900° under a muffle, it assumed a dull granular spongy texture and a dark black colour, without loss of weight. The lead had no doubt been added to render the metal fusible: and when once united, there is known to be great difficulty in again separating the metals. Platina cannot be purified by cupellation like gold, on account of its infusibility, which causes the alloy to solidify before the whole of the lead has been oxidized and driven off.

Having expressed a desire to obtain some of the native mineral in grains, Mr. **Lane** was so kind as to send a specimen which he had with difficulty procured in the course of the following year: but he was never able to send a second supply; so, being unwilling to consume the whole specimen in an analysis, I have contented myself with a rough examination of a small portion.

Before giving the results, however, it may be useful to bring together into one view the whole of the observations of the discoverer, and of Major **Burney**, on the locality and mode of extraction of this precious mineral.

Mr. **Lane**'s first announcement was expressed in the following terms:

" 'Mixed with the gold dust, found to the northward of Ava, are a quantity of grains of metal, having every appearance of iron; they are easily corroded, and are also affected by the magnet: by melting these grains, and keeping them in fusion, until the metal is no longer observed to scorify, the enclosed button of metal is left at the bottom of the crucible.

This metal, when mixed with gold, is found to increase its brilliancy. The King's ear-rings are made of a small quantity of it, mixed with pure gold; it is very brittle, and all our attempts have hitherto failed in making it malleable.' "

In addition to this information, Mr. **Swinton** *received the following* particulars from Major **Burney** in January 1832.

"'I find that a good deal of the platina ore is brought from some mountain torrents, or small streams, which fall into the *Kyendween* river from the westward, near a town called *Kannee;* and it is collected in a very curious manner, as Mr. Lane is informed, although he hesitates to believe the fact. The horns of a species of wild cow in this country called *Tsain*, perhaps the same as the *Nylgao* of India, have a velvet coat before the animal reaches the age of two or three years: a number of these horns are taken and fixed in the beds of the small streams, and at the close of the rainy season, when the water subsides, a cloth is put down over each horn separately; and the horns, and cloth, as well as a portion of the sand around them, are taken up together. The horns appear to collect around them a good deal of gold dust, which the streams have washed down, and with this dust grains of platina are found mixed.

The Burmese look chiefly for the gold dust, separating and bringing that alone generally to Ava; and although Mr. Lane has often urged the men who are engaged in this trade to bring at once the whole of what they take up with the horns, he has not yet been able to persuade them to do so. These horns sell sometimes for 12 or 13 *ticals* a piece: deer's horns are sometimes used instead of them.

The Burmese call platina, *Sheen-thán;* much of this ore is also found with the gold dust collected among the small streams which fall into the *Irawádi*, to the northward, in the direction of *Banman*.'"

ANALYSIS.

One hundred grains were taken for the determination of the specific gravity. They were immersed in water in a small glass tube, for which a counterpoise had been previously adjusted, and the air was taken out by exhaustion under the receiver of a pneumatic pump. 0.2 grains remained floating on the surface of the water, which, on examination with a microscope, proved to consist of spinel, augite, silex, and one very minute emerald

The specific gravity of the mixed grains at 75.° was 12.17.

Fifty grains, dried, were then taken for analysis.

1. From this were separated, under the microscope, 0.5 grains of gold.

2. The magnet removed also 0.4 of small black grains, supposed to be crystalized magnetic oxide of iron.

3. The remainder consisted of two portions, which were imperfectly separated; A, shining scaly grains of a silver colour; & B, dark black grains.

4. The white metallic scales (A) had a specific gravity of 9.10—the quantity separated weighed 8.5 grains. The black residue (B) weighed 40.6.

5. The silvery scales (A) were digested in boiling nitric acid, and caused a slight disengagement of nitrous fumes. The solution was not affected by muriatic acid, and consequently contained no silver; but carbonate of potash threw down a slight flocculent white precipitate, weighing less than 0.2 grains, which was not examined. It was probably carbonate of iron. The scales were then digested twice in boiling nitromuriatic acid, which acquired a deep orange colour, but left undissolved a portion of the scales and such of the black grains as had not been thoroughly separated from the rest: the weight of this residue was 3.7 grains.

6. The separated portion of dark grains (B) was also boiled several times in concentrated nitromuriatic acid, which took up 16.4 grains, and left untouched 24.2 grains, among which were discernible several of the shining scales not separated in the first instance.

7. The two nitromuriatic solutions were mixed together and treated with muriate of ammonia, which threw down a copious orange precipitate of the triple salt of platina, weighing 21.9 grains, which are equivalent to 9,45 of metallic platina, or nearly twenty per cent.

8. The solutions still retaining their orange red colour were treated with carbonate of potash, which precipitated at first mere oxide of iron and afterwards a bulky gelatinous precipitate of a light yellow colour, which was left unexamined for want of leisure, but which was supposed to contain a small portion of some earth mixed with carbonate of iron.

9. The undissolved residue of A and B, 27.9 grains, was mixed with caustic potash, and heated to redness in a platina crucible, according to the formula of WOLLASTON, to rid it of silicious matter which prevents the ready solution of the metallic grains. The fused mass was dissolved out of the crucible with weak muriatic acid, and was boiled in the same, imparting to it a bright yellow colour. The black grains remained in deposit, and were but little affected even by repeated boiling in nitromuriatic acid. The process was repeated with the same want of success. 21.82 grains of a fine heavy blue-black powder remained out of the original 28 grains: much of the difference must be attributed to the loss in such an operation upon a fine powder;—a part, however, is accounted for in the earths and iron taken up by the muriatic acid.

10. According to the experiments of R. BINGLEY, Esq., H.M. Assay-Master, at the London Mint, small portions of platina and its companion metals in alloy with gold may be separated by the ordinary process for refining gold, or quartation with silver and solution in nitric acid. I therefore endeavoured to obtain a solution of the refractory metal by uniting it with gold.

For this purpose, 2 grains of the black powder were wrapped up in a plate of pure gold weighing 20 grains, which was again enclosed in 50 grains of pure silver, and the whole fused together in a wind furnace. The bead exhibited black specks, as of iron oxide, on parts of its surface, but most of the powder had united with the compound metal.

On lamination and dissolution in the usual way, the nitric acid did not acquire any peculiar colour, and the gold cornet, when annealed, shewed the same spotted appearance as had been remarked in the button: it had a weight of 21 grains. On solution of this gold in nitromuriatic acid, the liquid took a dirty green colour from the suspension of a very fine dark blue powder, which quickly subsided, and had the same appearance as at first. The powder was placed in a Stourbridge clay crucible and urged in the heat of a forge until the crucible melted, without reduction of the powder to the metallic state; and it was only upon subjection to the oxihydrogen flame that it was agglutinated into a bright metallic sponge, similar to that of the iridium separated in the analysis of the platina button from *Ava*, before alluded to.

From the above imperfect examination, it appears that there is a predominance of iridium in the *Ava* platina ore to a much larger extent than in the ores from *South America* or from the *Ural* mountains. I hope hereafter to obtain a more copious supply of the mineral, and then to ascertain the presence of osmium and the other metals which usually accompany platina. The present note has been drawn up solely with a view to certify the interesting fact of the existence of platina among the gold washings of the *Ava* rivers; and in connection with that fact it may be farther stated, that the platina constitutes 20 per cent. of the cleaned ore, and that it is accompanied with about twice its weight of iridium. The remainder appears to be chiefly oxide iron.

INDEX.

A.

Alluvium of Guzerat, ... i 84
Aquila, of Nipal, ... ii 13
Argillaceous limestone of Hathi—Bundelkhand, ... i 28
Ava, Platina ore from .. .. .. ii 279
Azimuth, formula for calculating .. ii 93

B.

Baker, Captain, his experiments on Indian woods, ... ii 216
Basaltic veins in granitic rocks, .. i 21
——— rocks near Jebelpur, . i 40
——— varieties at Sagar, ... i 54
——— hill of Sitabaldi, .. . i 124
Baroda, geology of .. .. .. i 82
Barometrical altitudes of places in Bundelkhand, ... i 42
Bars, compensation, of Trigonometrical survey, ... ii 189
Betva River, geology of .. .. i 69
Bhilsa, geology of .. .. .. i 69
Bhopalpur, geology of .. .. .. i 49
Blossville M. de, magnetic observations of .. .. ii 1
Buceros Nipalensis, description of .. i 179
——— Homrai ditto,.. .. .. .. ii 169

C.

Calder, James, observations on Geology of India, ... i 1
Canis Vulpes, ... ii 236
Cataract of Kattra, i 26, of Bontí i 29, of Chochai i 127, of the Tons, i 27
Ceylon, geology of .. ... i 7
Coal district of the Damoda, ... i 163
Conglomerate, calcareous, of the Nermada, ... i 36 41
Coulthard on the Trap of Ságar, .. i 47

D.

Dangerfield's Geological Map, ... i 90
Diamond Brescia, described, ... i 10
——— Mines of Panna, ... i 100
Dolomite of Jabalpur, ... i 34
Dryness of the Air in Cashmir, ... ii 231
——— at Spiti, ... ii 240

E.

Everest, Captain, on formulæ for calculating Azimuths, &c. . .. ii 93
———, on the Compensation Bars of the Trig. survey, ... ii 189
———, Rev R.'s, Memorandum on Himalayan Fossils, ... ii 107
Expansion of Metals, ... ii 201

F.

Fossil Trees of Pondicherry, ... i 9
——— Shells of the Gawelgerh Hills, i 187
——— Limestone of Central India,.. ii 43
——— Shells of the Himálaya, ... ii 107
——— Sowerby's list of ditto, ii 278
Franklin, Captain J., on the Geology of Bundelkhand, ... i 23
——— on Panna Diamond Mines, ... i 100

G.

Geology of Central India, ... ii 27
——— of the Peninsula, ... ii 115
——— Nomenclature of ...... ii 30
——— of Pulo Penang, ... ii 149
——— of Queda Country, ... ii 164
Gerard, Dr.'s Himalayan Fossils, .. ii 107
——— on the Spiti Valley, ... ii 238
Gold Mines of Siam, ... i 143
Grallatores of Nipal, ... ii 122

Granite, basis of Peninsula, .. i 37 ii 60
———, at Herapur, ... i 75
Guzerat, Alluvium of .... i 84
Gypsum of the Himálaya, ... i 216

H.

Hardie, J. Dr., on the country between Baroda and Udayapur. .... i 82
——— on Geology of Central India, ii 27
Herapur Granite, ... i 75
Heyne, Dr.'s remarks on Geology of Hyderabad, ... i 11
Herbert, Capt. J. D. on Indogangetic Gypsum, ... i 216
———, on Himálayan Minerals, .. i 227
Hodgson, B. H. on a new species of Buceros, ... i 178
———, Aquila Nipalensis, ... ii 13
———, Circætus Nipalensis, ... ii 17
———, Dicrurus Nipalensis, .. ii 21
——— on the Migration of Nipal Birds, ... ii 122
———, Wild Goat and Wild Sheep, ii 127
———, Ratwa Deer, ... ii 170
———, Buceros Homrai, .. ii 139
———. Wild Dog, ... ii 221
Hodgson, Col. J. A. Magnetic Observations at Calcutta, ... ii 1
Hot fountain of Moulmein, ... i 154
——spring of Chitor, ... ii 53

I

Inundations of the Hugli, . . i 221
Iron Mines of Siam, ... i 145
——— Ores, Analysis of .. .. i 171

J.

Jabalpur, Geological situation of, i 33 barometrical altitude of .. i 45
Jenkins, Capt. T., on Nagpur minerals, i 155
Jones on the Burdwan Coal district, .. i 163

K.

Kamti. Geology of .. .. i 203
Kankar formation, considerations on i 17
——— at Salambhar, i 84 ii 02
Kutch, recent Rocks of, ... i 87
Kyd, James, on the Tides of the Hugli, i 259

L.

Laterite Formation, Buchanan's Observations on .... i 4
Lias, Formation resembling it in India, i 29 [illegible]
——— at Hutta, ... i 61
Limestone, Shell, of Pondicherry, .. i 9
———, singular variety of, at Sagar, 30 59
Low, Captain James, on Geology of Malaya, ... i 128

M.

Macpherson's, Lieut. S. C., on the Geology of the Peninsula, ... ii 115
Magnetic Inclination, &c. at Calcutta, ii 1
Malayan Peninsula, Geology of .... i 128
Marwar, Geology of .... ii 75
Measurement, by compensation bars, ii 214
Minerals and Metals of Himálaya, .. i 222
Mountain ranges of India, ... i 2

N.

Nagpur, Geology of .... i 121
——— Minerals, ... i 195
Nasirabad, ... ii 81
Natatores of Nipal, ... ii 122
Nipal Birds, ... i 179 ii 12 17 23 169
——— Migrations of ditto, ... ii 122
——— Wild Goat, description of .. ii 124
——— Ratwa Deer, ... ii 141

P.

Pannah, Diamond Mines of .. .. i 100
Penang, Geology of .... ii 149
Peninsula, Geology of .... ii 115
Piddington's, H., analysis of Iron ores i 171
——— on the fertilizing principle of the Hugli, ... i 224
Platina, discovery of, in Ava, ... ii 279
Prinsep, J., Analysis of platina, ... ii 279

Q.

Quartz, remarkable extent of .... i 91
Queda Country, Geology of .... ii 164

R.

Ratwa Deer of Nipal, ... ii 139

S

Sagar, Geology of, by Capt. Franklin, i 23
——— on the Trap of, by Capt. Coulthard, ... i 47
Sandstone near Mirzapur, ... i. 24 39
——— rising through trap of Sagar, i 47
——— new red of Bindachal, i 102 ii 64

Schists of Central India, ... ii 67
Siam Alluvium, ... i 125
Sitabuldi Hill, Geology of .... i 123
——————, Minerals, ... i 194
Soil, Analysis of Hugli, ... i 225
Sowerby's Note on Himalayan Fossils, ii 277
Spiti, description of the Valley of, ii 235 247

T.

Table of Indian Woods, .. . ii 216
Tenasserim Coast, ... i 156
Tibet, Gerard's Account of .. .. ii 256
Tides of the Hugli, Tables of .. i 259
Tin Mines, Malay, . .. i 137
Trap Formation of Central India, i 3 30 39
——— runs towards Amerkantak i 35
——— sudden termination of . i 73
Tuta, same as Kankar, ... i 51

V.

Vegetable impressions in Shale, .. ii 40
Vindya Chain, Geology of .. .. i 13
Voysey, Geology of India indebted to him, ... i 10
——— on the geology of Nagpoor, .. i 123
——— on Petrified Shells of Gawelghar Hills, ... i 187

U.

Udayapur, Geology of .. . i 81 83

W.

W[illegible] of Sagar, . . i 57
Ward, Dr. J. on the Geology of Penang, ii 119
Wild Dog of the Himalaya, .. ii 221
Wood, Indian, Table of Elasticities, &c. 216

LIST OF PLATES.

FIRST PART.

1.—Key to Arrowsmith's Map of India, to face page 1
2.—Geological Map of Bundelkhand 46
3.—Geological Section of ditto, ... 46
4.—Geological Sketch of Bhopal, Bhilsa, &c 80
5.—Sketch of Sagar and the Vicinity, ... 80
6.—Route from Baroda to Udayapur, ... 99
7.—Geological Section from Baroda to [illegible] 99
8.—Map of the Panna Diamond Field, ... 122
9.—Coal Measures of the Burdwan District, ... 170
10.—Plan of the Colliery at Raniganj 170
11.—The Buceros Nipalensis, ... 186
12.—Ditto Figure 2, ... 186
13.—Geological Sketch of the vicinity of Nagpur, ... 214
14.—Sections from Bangalore to Cape Comorin, &c 214
15, 16, 17, 18, 19.—Tide Tables of the River Hugli, ... 268

SECOND PART.

20.—Aquila Nipalensis, ... 16
21.—Circaetus Nipalensis, ... 20
22.—Dicrurus Indicus, (Bhúchàng,) 26
23.—Organic Remains in the Nimach Limestone, ... 92
24.—Section from Nimach to Merta, ... 92
25, 26, 27.—Himaláyan Fossil Shells, 3 Plates, ... 114
28.—The Jharal, or Wild Goat of Nipal, ... 131
29.—The Nyaur, or Wild Sheep of ditto, ... 138
30.—Horns and Skull of ditto, ... 138
31.—Head of the Ratwa Deer, ... 146
32.—Geological Map of Pulo-Penang, ... 163
33.—Sections of ditto, ... 163
34.—Buceros Homrai of Nipal, ... 188
35, 36.—Compensation Bars of the Trigonometrical Survey, ... 214
37.—Wild Dog, Fox, and Jackal of India, ... 236
38, 39.—Skulls of ditto, ... 236

Or the Plates may be collected at the end of the volume.

Granite, basis of Peninsula, .. i 37 ii 60
———, at Herapur, ... i 75
Guzerat, Alluvium of .... i 84
Gypsum of the Himálaya, ... i 216

H.

Hardie, J. Dr., on the country between Baroda and Udayapur. .... i 82
——— on Geology of Central India, ii 27
Herapur Granite, ... i 75
Heyne, Dr.'s remarks on Geology of Hyderabad, ... i 11
Herbert, Capt. J. D. on Indogangetic Gypsum, ... i 216
———, on Himálayan Minerals, .. i 227
Hodgson, B. H. on a new species of Buceros, ... i 178
———, Aquila Nipalensis,.... . ii 13
———, Circætus Nipalensis,...... ii 17
——— ———, Dicrurus Nipalensis, .. ii 21
——— — on the Migration of Nipal Birds, ... ii 122
———, Wild Goat and Wild Sheep, ii 127
———, Ratwa Deer, ... ii 170
———, Buceros Homrai, .. ii 139
———. Wild Dog, ... ii 221
Hodgson, Col. J. A. Magnetic Observations at Calcutta, ... ii 1
Hot fountain of Moulmein, ... i 154
——spring of Chitor, ... ii 53

I

Inundations of the Hugli, . . i 221
Iron Mines of Siam, ... i 145
——— Ores, Analysis of .. .. i 171

J.

Jabalpur, Geological situation of, i 33 barometrical altitude of .. i 45
Jenkins, Capt. T., on Nagpur minerals, i 156
Jones on the Burdwan Coal district,.. i 163

K.

Kamti. Geology of .. .. i 203
Kankar formation, considerations on i 17
——— at Salambhar, i 84 ii 92
Kutch, recent Rocks of, ... i 87
Kyd, James, on the Tides of the Hugli, i 259

L.

Laterite Formation, Buchanan's Observations on .... i 4
Lias, Formation resembling it in India, i 29 [illegible]
——— at Hutta, ... i 61
Limestone, Shell, of Pondicherry,.. i 9
———, singular variety of, at Sagar, 30 59
Low, Captain James, on Geology of Malaya, ... i 128

M.

Macpherson's, Lieut. S. C., on the Geology of the Peninsula,........ ii 115
Magnetic Inclination, &c. at Calcutta, ii 1
Malayan Peninsula, Geology of .... i 128
Marwar, Geology of .... ii 75
Measurement, by compensation bars, ii 214
Minerals and Metals of Himálaya, .. i 222
Mountain ranges of India, ... i 2

N.

Nagpur, Geology of .... i 121
——— Minerals, ... i 195
Nasirabad, ... ii 81
Natatores of Nipal, ... ii 122
Nipal Birds, ... i 179 ii 12 17 23 169
——— Migrations of ditto, ... ii 122
——— Wild Goat, description of .. ii 124
——— Ratwa Deer, ... ii 141

P.

Pannah, Diamond Mines of .. .. i 100
Penang, Geology of .... ii 149
Peninsula, Geology of .... ii 115
Piddington's, H. analysis of Iron ores i 171
——— on the fertilizing principle of the Hugli, ... i 224
Platina, discovery of, in Ava, ... ii 279
Prinsep, J., Analysis of platina,.... ii 279

Q.

Quartz, remarkable extent of .... i 91
Queda Country, Geology of .... ii 164

R.

Ratwa Deer of Nipal, ... ii 139

S

Sagar, Geology of, by Capt. Franklin, i 23
——— on the Trap of, by Capt. Coulthard, ... i 47
Sandstone near Mirzapur, ... i. 24 39
——— rising through trap of Sagar, i 47
——— new red of Bindachal, i 102 ii 64

CALDER, JAS. ESQ.— A series of specimens containing Organic Remains from the neighbourhood of the Giants' Causeway in Ireland—Species of Mollusca from the Coast of Ceylon—Geological specimens from the vicinity of Simlah, and from the Himalaya Range—Specimens of the Fossil Bones from the neighbourhood of Prome in Ava.

CAUTLEY, LIEUTENANT.—Specimen of a Trap Rock or Dyke, discovered near Masuri.

COULTHARD, CAPTAIN.—Geological Specimens from Sagar.

CRACROFT, W. Esq.—Specimen of the Coal Strata lately discovered at Sanarim and near the Sanatarium, in the Kasya Hills—Series of Rocks and Minerals from Chira Punji—Specimens of Limestone of the Sylhet Quarries.

CROMMELIN, LIEUTENANT J. A.—Specimen of Fossil Ammonite from the Carboniferous Limestone of Swansea.

DAVIDSON. CAPTAIN.—A large Square Brick, dug up at Goalpara in Assam.

DESJARDINS. MONSR. J.—Specimens of the Scincus Bojerii and the S Boutonii and the Sqille de 'l I. Maurice, preserved in Spirits, and some Fossil bones of the Turtle, discovered in an estate at Flacq.

DUFF. W. ESQ.—Specimens of Minerals from the Goomadong Hills.

DUNCAN, DR.—Fossil bones of an Elephant found in the river near Culpee.

EVEREST, REVEREND R.—Specimens of Vegetable impressions in the Coal and Shale of Raniganj—Geological specimens from the Ramgerh District.

FINNIS, LIEUTENANT I.—Specimens of the Minerals in and near the coal veins at Hassingabad.

FRANKLIN, CAPTAIN F.—Geological Specimens of Sagar and Jubalpur, from Bundlekhand, Boghelkhand.

GERARD, DR. J.—A series of Fossil Shells from the Himalayan Mountains.

GOVAN, DR.—Rock specimens from the vicinity of Simlah—A fragment of Calcareous Rock of Soobathoo—Organic remains from the Satlez.

GREY, SIR CHAS. E.—On Europe, a Cabinet of Mineralogical and Geological specimens, comprising a large collection of Indian specimens—Series of Rocks at Penang and the neighbouring Islands.

GRIERSON, DR. J.—Specimen of the long-eared Bat (Vespertilio Auritus.)

HARDIE, DR.—Specimens of Lias Limestone with Organic Remains—Mineral Specimens from Central India—Biana.

HEATH, J. ESQ.—Specimens of the Iron Ores of the Salem Hills.

HENDERSON, DR. J.—A sample of the Petrified Wood of Van Diemen's Land.

HODGSON, B. H. ESQ.—Specimens of the Copper Ore from Nipal.

HODGSON, COLONEL.—A Geological Map of England.

HUTCHINSON, CAPTAIN.—A stuffed Albatross.

KERR, MR. Specimens of Copper Ore from Nellore.

LANGSTAFF, DR. J. Specimens of Sandstone at Sikrigali with Vegetable impressions of Ferns, &c.

LESLIE, DR.—Drawings of a Doe and its Skull.

LEA, PROFESSOR.—Specimens of American Shells.

LEWIS, MR.—A specimen of Rock from the summit of Mount Ophir, Malacca.

LLOYD, LIEUTENANT R.—A series of Geological specimens of the Rocks in the Tennasserim Archipelago.

MALCOLMSON, DR.—Fragment of Bone, from a cave in the neighbourhood of Hyderabad.

MORISON, COLONEL W.—Specimen of the Garnet Sand from Cape Comorin and some Fossil Seeds.

NOTON, B. ESQ.—Specimens of Zeolites from Bombay.

PEARSON, DR. J. T.—A stuffed specimen of a species of Felis, native of the Midnapur Jungles.

RAVENSHAW, E. C.—Specimens of Coal from the North Moradabad District.

RICHARDSON, D.—Specimens of the Coal from Gendah, on the Neengtee, or Kuenduen River.

Rose, R. Esq.—Geological specimens from Midnapore, Sumbhalpore and Balasore.

Ross, D. Esq.—Specimens of Anthracite from the Karakpur Hills near Bhagulpur—Specimens of Bituminous Coal from the banks of the Warda River near Chanda.—Also Specimens of Clay and Quartzy Sand, from the experimental Boring in the Fort of Calcutta.

Royle, Dr. J.—Geological specimens from Rajpur Masuri, in the Dehra Doon—Specimens of Rocks from the new Benares Road.

Ryan, Sir Edward.—Series of Volcanic specimens from Mount Vesuvius.

Sage, Captain W.—Specimens of the Coal from the Coal Field of Palamoo.

Scott, Mr.—A series of Stalagmitic Balls from the Cossyah Hills—three boxes of Minerals from Assam and Sylhet.

Smith, Mr.—Specimens of Lithographic Printing from Stones of Bundelkhand, Agra and Rotas.

Smith, Lieutenant T.—Geological specimens of the late Dr. Voysey.

Spilsbury, Dr. G. G.—Specimens of Fossil Bones from Jabalpur and in its neighbourhood.—Silicified Shell Brescia, from Jubalpur.

Stewart, Major Joseph.—Specimens of Sandstone from Agra.

Strong, Dr. F. P.—Specimens of the Clay obtained by boring near the Salt Water Lake, and in Fort William—Peat earth from Dum-Dum road.

Telfair, C.—Fossil Bones from the Isle of France, and a specimen of the Silk produced from the Madagascar Worm—a collection of Geological specimens and Minerals.

Thomson, Lieutenant J. (Engineers.)—Geological specimens from Gyah and Rotas Garh.

Walters, H. Esq.—A box of Rock specimens and Minerals from the Casiya Hills—Geological specimens and Coal from Arracan and Ramree.

Ward, Mr.—Specimens of the Calcareous Deposit found about the hot spring in Bencoolen.

Watson, Colonel T. C.—A Model of Theodore Jones & Co.'s Suspension Wheels.

APPENDIX.

MEMBERS OF THE ASIATIC SOCIETY,—1833.

Patrons.

he Right Honorable Lord WILLIAM CAVENDISH BENTINCK, G. C. B. and G. C. H., *Governor General, &c. &c.*

is Excellency General Sir EDWARD BARNES, G. C. B., *Commander-in-Chief.*
he Honorable Sir C. T. METCALFE, Bart., *Vice President.*
he Honorable WILLIAM BLUNT, Esq.
Members of the Supreme Council.

RESIDENT.—The Honorable Sir EDWARD RYAN.
ICE-PRESIDENTS.—The Honorable Sir J. FRANKS.
Honorable Sir C. T. METCALFE, Bart.
The Rev. Principal W. H. MILL.

Committee of Papers.

THE PRESIDENT, VICE-PRESIDENTS, SECRETARY, AND MEMBERS;—Viz.

he Honorable Sir E. RYAN, *President*
he Honorable Sir J. FRANKS,
he Honorable Sir C. T. METCALFE, Bart.
he Rev. Principal W. H. MILL.
Vice-Presidents.

Rev. Dr. W. CAREY.
J. CALDER, Esq.
J. TYTLER, Esq.
Captain A. TROYER.
Rev. T. PROCTOR.

J. R. COLVIN, Esq.
Baboo RAMCOMUL SEN.
D. HARE, Esq.
Dr. J. T. PEARSON.

gent in Europe.—HORACE HAYMAN WILSON, Esq.
cretary.—JAMES PRINSEP, Esq.
ative Secretary.—Baboo RAMCOMUL SEN.
brarian and Superintendent of the Museum.—Dr. LOUIS BURLINI.
ssistant Librarian.—HERAMBANATH THAKOOR.
reasurers.—The BANK OF BENGAL.
llector.—Baboo RAMCOMUL SEN.
ooksellers in England.—Messrs. PARBURY, ALLAN & CO.
itto for the Continent.—Messrs. DONDEY, DUPRE & CO.

Physical Class.

President.—The Honorable Sir E. RYAN.
Vice-President.—JAMES CALDER, Esq.
Secretary.—JAMES PRINSEP, Esq.

All Resident Members of the Society are Members of the Committee.

Members.

A

Achmuty, J.
Ainslie, M.
Anbury, Col. Sir Thomas
Ashburner, J.
Atkinson, J.
Avdall, J.

B

Bagshaw, R. J.
Baillie, Colonel John
Baillie, N. B. E.
Balfour, Francis, M. D.
Bateman, Rev. Joseph
Bayley, Hon'ble W. B.
Benson, Major R
Berry, Andrew, M. D.
Biddulph, Robert
Bird, W. W.
Brightman, E.
Briggs, Colonel John
Brook, Thomas
Bryant, Lieut.-Col. Sir Jeremiah
Buckley, Captain W.
Buller, Sir Antony, Kt.
Bunwari, Govind Roy, Raja
Burke, W. A., M. D.
Burney, Major H.
Burnes, Lieut. A.
Burroughs, Sir Wm., Bt.

C

Calder, James
Caldwell, Major H.
Carey, Rev. Dr. W.. D. D.
Cautley, Captain P. T.
Chester, G.
Casanova, Dr. J.
Clemmishaw, T.
Colebrooke, Sir J. E., Bt.
Colebrooke, Major W.
Colebrooke, H. T.
Colvin, J. R.
Compton, Sir Herbert
Cooper, H.
Coulthard, Captain T.
Cowles, Captain C.
Crawfurd, J.
Crisp, Captain J.

D

Daniel, Thomas
DeNoyé, Dr.
Dillon, Captain P.
Dobbs, A.
Dowdeswell, George
Doyle, Lieut.-Col. C. J.
DuBois de Beauchesnea.
Dundonald, Hon'ble Lord
Dwarakanath Tagore.

E

East, Sir E. Hyde, Kt.
Edmonstone, N. B.
Egerton, C. C., M. D.
Ellis, Captain E. S.
Erskine, Wm.
Everest, Majo. G., F. R. S. F. A. S. &c.
Everest, Rev. R.
Ewer, W.

F

Ferguson, J. H.
Fombelle, John
Forbes, Captain W. N.
Francis, R. B.
Franklin, Captain J.
Franks, Hon'ble Sir J.
Fraser, J. B.
Fraser, Captain J.
Fullarton, John, M. D.

G

Gerard, Captain A.
Gilchrist, J. B., L. L. D.
Goldingham, J.
Goodwin, R. T.
Gordon, G. J.
Gordon, Lieut. A. D.
Grant, W. L.
Grey, Hon'ble Sir C. E.

H

Hale, E.
Hall, Captain B.
Hamilton, Lieut.-Col. Wm.
Hamilton, R. N. C.
Hardwicke, Major-General T.
Hare, D.
Hardy, J.
Harriott, Colonel J. S.
Herbert, Captain J. D.
Hodgson, Lieut.-Col. J. A.
Hodgson, Henry
Hodgson, B. H.
Hogg, J. W.
Home, R.
Howison, James

J

Jackson, Dr. A. R.

K

Kalikissen, Moha Raja, Bahadoor
Keating, Colonel C. H.
Keene, Henry George
Kelso, Alexander Hamilton
Kennaway, Sir John B.
Kyd, James

L

Lachlan, Captain R.
Larruleta, M.
Lewin, T.
Lloyd, Charles
Lloyd, Lieut.-Col. Herbert
Low, Captain Jas.
Lumsden, Dr. M., L. L. D.
Lushington, G. T.

M

Macaulay, Col. Colin
Macdonald, Col. Alex.
Macdougall, Captain J. P
Mackenzie, Holt
Mackenzie, Captain J.
Mackillop, G.
Macnaghten, Sir Francis W., Kt.
Macnaghten, W. H
Macan, Captain T.
McFarlan, D.
McQueen, Rev. J.
Malcolm, Major-Genl. Sir J.
Mansell, C. G.
Manuk, M. M.
Marsden, Wm.
Marshman, Rev. Dr. Joshua
Marshman, J. C.
Martin, Wm. Byan
Martin, Dr. R. M.
Martin, C. R.
May, J. S.

McWhirter, John, M. D.
Melville, Hon'ble W. H. L.
Mendes, Francis
Metcalfe, Hon'ble Sir C. T., Bt.
Middleton, Nathaniel
Mill, Rev. Prinl. Dr. W. H.
Money, G.
Moore, Major Edward, F. R. S.
Morrison, Captain M.
Mundt, Dr. C.

N.

Nicolson, Dr. Simon
Neave, R.

O

Oliver, Wm.
Ouseley, Sir George, Bt.

P

Palmer, John
Parson, Rev. J.
Patterson, Col. Wm.
Pearson, J.
Pearson, Dr. J. T.
Pemberton, Captain R. B.
Price, Major W.
Prinsep, H. T.
Prinsep, C. R.
Prinsep, James
Proctor, Rev. T.

R

Radhacaunt Deb, Baboo
Rujchunder Doss
Ramcomul Sen
Ravenshaw, C. E.
Renny, D. H.
Richy, Monsr. A. L.
Ricketts, Chas. Milner
Roberts, B.
Robertson, Rev. T.
Robinson, Ven. Archdeacon
Robison, C. K.
Romer, John
Ross, Jas.
Ross, D.
Royle, J. F.
Russell, Sir Henry
Russomoy Dutt
Rutherford, T.
Ryan, Hon'ble Sir E.

S

Sage, Captain W.
Scott, Lieut.-Col. Richard
Sherer, John Walter
Seppings, J. M.
Sibchunder Doss
Smith, Courtenay
Smith, R. P.
Stewart, Major J. W.
Stewart, Col. Mathew
Stewart, Hon'ble C. F.
Stewart, Jas.
Stirling, E.
Stirling, Capt.
Strange, Sir Thos.
Strong, F. P.
Sulley, B. C., M. D.
Sutherland, J. C. C.
Swinton, G.
Syamlal Tagore

T

Taylor, Lieut.-Col.
Teignmouth, Right Hon'ble Lord
Thomason, J.
Thompson, John

Thompson, George
Tod, Major Jas.
Trail, Henry
Trant, W. H.
Trevelvan, C.
Trotter, Archibald
Trotter, John
Troyer, Capt. A.
Tucker, Henry St. George
Turton, T. E. M.
Twining, Wm.
Tytler, J.

W

Walker, Captain W.
Wallich, N., M. D.
Walpole, Major H.
Warren, Lieut.-Col. John
Watson, Col. T. C.
Webb, Major W. S.
White, Major F. S.
Wilcox, Captain R.
Wilkins, Charles
Williams, John Lloyd
Wilson, H. H.
Withers, Rev. G. U.
Wynch, P. M.

Y

Young, James
Young, Rev. Dr. J.

Honorary Members.

Dr. Belanger.
Mons. de Blosseville.
Professor Bopp.
Mons. Burnouf.
Mons. Chezy.
Right Honorable Earl of Munster.
Baron Richmont de Debassayn.
Professor Fischer.
Professor Fraehn.
Henry Sullivan Greme, Esq.
Joseph Von Hammer.
Professor John Jameson.
Mons. Lassen.
Mons. Langbois.
Mons. 'Du Marcel.
Count de Noe.
Professor Oersted.
Sir Wm. Ouseley.
Sir R. Palmer.
Sir John Phillipart.
Professor Rasmussen.
Mons. Remusat.
Professor A. Schlegel.
Baron Sylvester de Sacy.
Mons. Garcin de Tassy.
General Walker.
Desjardins, Mons. J.
Horton, Sir R. W.
Malkin, Sir Ben.
Telfair, C, Esq.

STATE CEN
WEST